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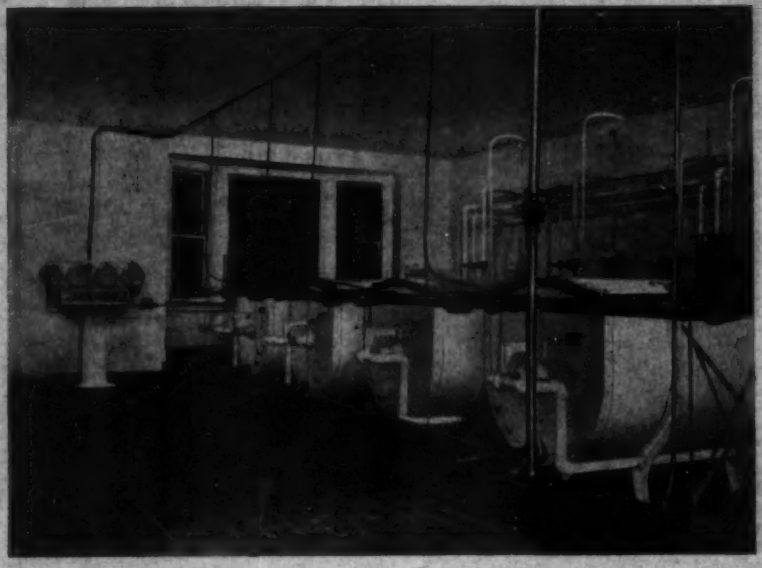

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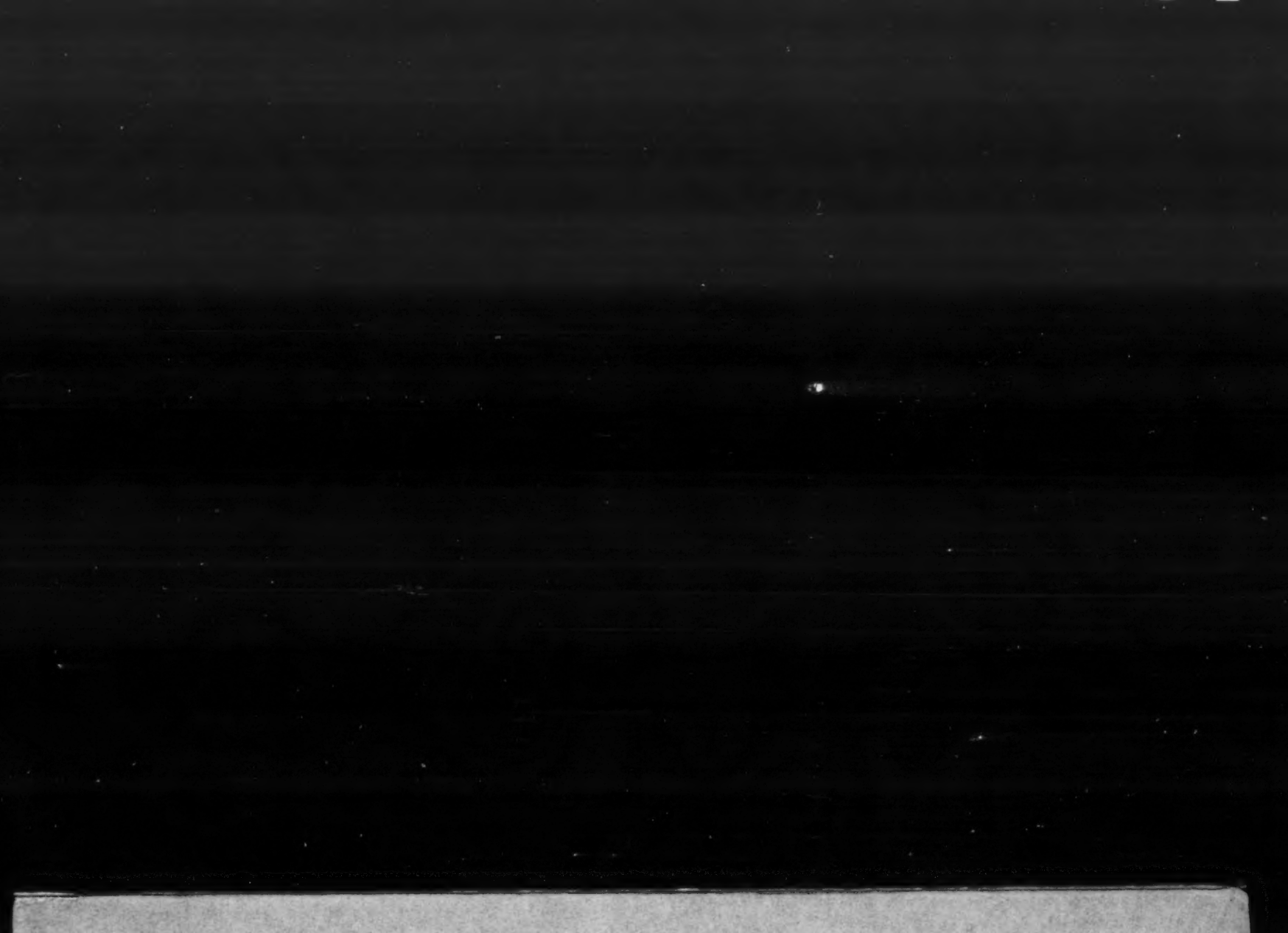

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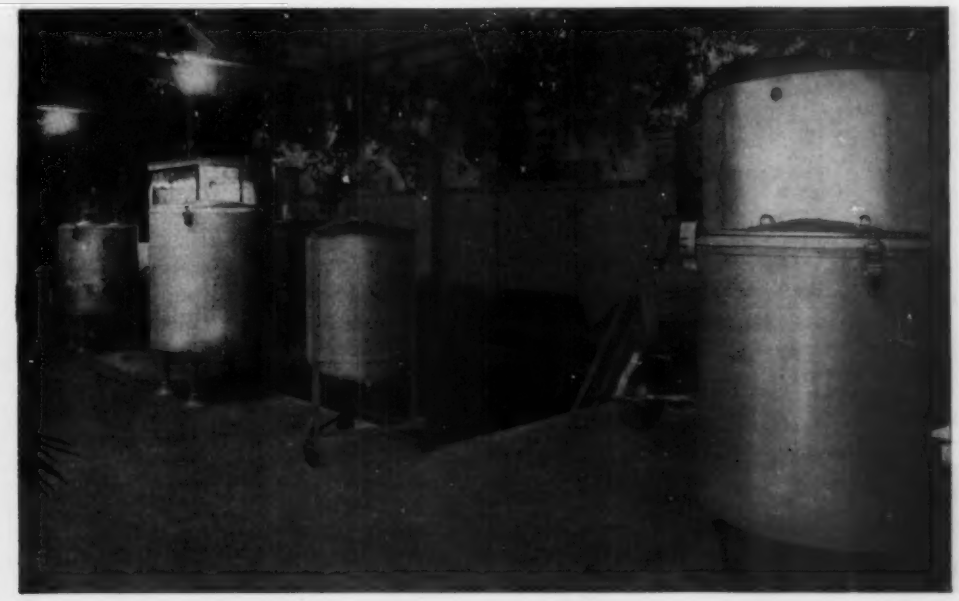

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THE VITAMIN B REQUIREMENT OF THE CALF[1]

S. I. BECHDEL, C. H. ECKLES AND L. S. PALMER

Five vitamins are now known to be important in human and animal nutrition. Some of them are more important in the life of certain species than they are in others. For example, the antiscorbutic factor does not appear to be necessary in the ration of the calf, the pig, the rat, or the chicken, while it is essential in the ration of man or the guinea pig. On the other hand, the rat and the chick have rather heavy demands for the antirachitic factor while swine appear to tolerate a relatively low supply. The extent to which the results with laboratory animals can be applied to the larger domestic animals, is, therefore, questionable.

Eckles, Palmer et al. (1) studied the effect of yeast as a supplemental feed to rations ordinarily fed to calves from 20 to 180 days of age. The results were negative since no increase on the rate of growth or beneficial effect on the health of the calves could be observed. Eckles and Williams (2) made a similar study with lactating cows and obtained negative results. The outcome of these studies make it apparent that there is no advantage in feeding a vitamin B supplement to the rations commonly fed to calves and lactating cows in good dairy herds.

In a search of the literature no reference could be found concerning a systematic study to determine whether the growing calf requires a supply of vitamin B in its ration similar to that found necessary for the growth of laboratory animals. This

[1] Received for publication May 15, 1926. Published by permission of the Directors of the Minnesota and Pennsylvania Experiment Stations as paper number 617, and paper number 409, Journal Series, of the respective stations.

The data presented in this paper are from a thesis submitted by S. I. Bechdel in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Graduate School of the University of Minnesota. The experiments were planned and the preliminary work done in the Divisions of Dairy Husbandry and Agricultural Biochemistry, University of Minnesota. The final experiments were financed and conducted in the Departments of Dairy Husbandry and Agricultural Biochemistry, The Pennsylvania State College.

paper is intended to set forth the results of an investigation which was designed to throw light upon this question.

Theiler and associates (3) have made a contribution in their studies of the disease in South African cattle known as lamzietke. In the course of their investigations rations consisting of polished rice supplemented with a small amount of autoclaved roughage (Veldt hay and oat straw) were fed to cattle for periods ranging from 44 to 52 weeks with no evidence of beri beri symptoms. Theiler suggested the possibility of cattle being able to synthesize vitamins by means of bacterial symbiosis in the digestive tract.

FUNCTION OF VITAMIN B

Vitamin B is commonly referred to as a growth promoting vitamin, although it possibly may include two factors, viz., the antineuritic vitamin, the absence of which causes polyneuritis in fowls and beri beri in man, and a water soluble growth promoting substance. Sherman and Smith (4) after studying all the investigations on vitamin B up to 1922, state that the absence of this factor from the diet causes cessation of growth, that a partial but not complete deficiency of this vitamin leads to impaired growth and a general undermining of health and vigor, and this lowered vitality may have a far reaching effect in its influence on reproduction and the successful rearing of young.

EXPERIMENTAL

The selection of a palatable ration that carries all of the known dietary factors for growth and well being of calves, excepting vitamin B, offers a real problem since all of the common hays and cereal grains as well as milk and milk powders are known to contain a considerable amount of this vitamin. The liberal use of by-product feeds offers the only solution.

It was expected that the employment of such a ration would involve other dietary factors, since none of the principles of vitamin nutrition had been applied to cattle or the other larger

domestic species at the time of starting the investigation in 1922. As was more or less expected some mistakes were made in the first attempts, and the early results are reported as preliminary experiments. The major part of the data is presented as the main experiments. The main portion of the study covers the period in the life of the calf between five and thirty months of age while a limited amount of data are presented on the period between birth and five months of age.

Preliminary experiments

Ration. Feeding trials on rats (5) had indicated that corn gluten feed and commercial dried sugar beet pulp, when added to the ration in such proportion as would be suitable for calves, carried little or none of the water soluble B growth factor. With this information at hand it was planned to formulate an experimental calf ration as follows:

Feed	pounds
Corn gluten feed	100
Casein	50
Polished rice	50
Butterfat	25

A commercial grade of casein was used, as a more highly purified product would have been prohibitive. Polished rice is generally conceded to be devoid of vitamin B, while butterfat is considered a good source of vitamin A. At this time (1922) definite information on the anti-rachitic factor was not available, so that no provision was made for supplying it in the ration.

The butterfat in a melted condition, after being decanted, was mixed with the concentrate mixture. A quantity sufficient to last for about two weeks' feeding was prepared at one time. Dried beet pulp was depended upon solely to supply roughage.

Two bull calves, one a Holstein, S-3, 8 months of age, and the other a Jersey, S-6, seven months of age, were selected for the preliminary trial. These animals, about normal in size, had been raised on the usual skim-milk and grain ration. They were confined in box stalls and fed the experimental ration in a dry

condition in such amounts as they would consume from day to day. Records of the feed consumption, live weights at ten day intervals, and height at withers at 30-day intervals were kept on these as well as subsequent experimental animals, but for the sake of brevity these data are omitted.

The two animals got along nicely on the ration for about 100 days. They then began to exhibit signs of stiffness and did not have full control of their legs in walking. They also went off feed. The addition of vitamin B (10 per cent of dried yeast) to the ration of the Holstein, S-3, failed to give any relief, and at 113 days on experiment he went entirely off feed. He had a severe form of scours and at this time it was discovered that he was almost blind. A white spot appeared on the center of one eye ball. A profuse mucous discharge ran from his nose almost continuously. Fourteen days of the yeast treatment failed to afford any relief, and wheat germ, ½ pound daily produced no improvement. The daily feeding of the juice of two oranges to supply vitamin C was tried without results. On the 120th day fit-like spasms occurred, in which he would fall down and be unable to get back on his feet for a time. The administration of two ounces daily of cod liver oil brought almost immediate improvement. He came back on full feed, and when taken off the experiment at 220 days he was 122.4 per cent normal in weight. The cod liver oil was continued for a period of 18 days but the wheat germ was continued to the end of the experiment.

Results with the Jersey bull, S-6, were much the same as those exhibited by the Holstein. He continued along for about two months gradually showing more and more signs of malnutrition. He displayed the same profuse nasal discharge as the Holstein. On the 166th day of the experiment he was given cod liver oil in two ounce daily doses. At about this time it was discovered that he had pneumonia. The cod liver oil was discontinued after ten days feeding and daily doses of five pounds of wheat germ were given. Five days later the juice of two oranges were administered daily. He gradually recovered and came back on full feed, but was again stricken with pneumonia and taken off the experiment.

At the time it was impossible to draw any conclusions from the results obtained on these two preliminary animals. No definite proof was obtained that the addition of vitamin B to the ration offered any relief. The addition of cod liver oil appeared to afford the most relief, but all of the credit could not be assigned to it since vitamins B and C were administered at about the same time. Further comment, and what is now believed to be a satisfactory explanation, will be presented following the discussion of results on the second preliminary experiment.

Second preliminary experiment

A repetition of the preliminary trial with a larger number of animals appeared to be the next logical step. The ration employed was the same, except for the addition of the following minerals:

12.0 pounds calcium carbonate (precipitated chalk)
1.5 pounds acid potassium phosphate
0.875 pound ferric citrate
0.313 pound potassium iodide

Animals. Four grade Holstein animals, approximately 8 months of age were selected. Three of them, B-4, B-10, and E-5 were bulls. One, E-6, was a free martin. They had been fed the usual skim-milk, grain, and hay ration.

Calves E-5 and E-6 received the experimental ration without supplements. Tomato juice and wheat germ to supply vitamins B and C were supplements to the ration of B-4 which was selected as a check animal. Two ounces of cod liver oil were added daily to the ration of B-10 in order to get further information on its apparent curative effect on the calves in the previous experiment.

Results of second preliminary experiment. Animal B-10 that received the cod liver oil supplement continued along on the ration for over a year and made most excellent growth and development. He was found normal in every respect when slaughtered at the close of the experiment. He showed no signs of vitamin B deficiency at any time in his career.

Animal B-4 thrived well until on experiment 108 days when he developed a stiffness in all parts of his body. He almost entirely refused to eat; his knees and ankles became swollen; and he developed a tendency to stand with his hind legs forward, so that his body was in a squatty position. He appeared to give much evidence of rickets as observed in other animals. Daily doses of 2 ounces of cod liver oil were given. About two months previous to this time, on account of repairs being made at the experimental barn, the animals were confined in the main barn. In these quarters they did not get daily out-of-door exercise as they did before. In the light of our present understanding of the importance of sunlight in nutrition, it would be reasonable to suppose that this condition might never have arisen had out-of-doors exercise been provided continuously.

The cod liver oil was increased to 4 ounces daily after five days and this amount was continued throughout the experiment. Inprovement was observed in a few days, but it came about very slowly. The animal did not eat well, especially of the grain. On account of the unpalatability of the wheat germ it was left out of the ration on the 146th day of the experiment. The daily doses of 350 cc. of tomato juice being fed at this time were believed to be sufficient for any needs of vitamins B and C that this animal might have. He ate the ration more freely after the wheat germ was left out and on the 158th day was much better. He did not get back on to full feed until the 220th day of the experiment. All signs of the rachitic condition had disappeared by this time. At 320 days on experiment he was up to normal in weight and above normal in height. When put on an alfalfa hay and grain ration he gained more rapidly than on the experimental ration, but his gains were not phenomenal. When slaughtered no indication of abnormal condition could be found. In view of the results before and after feeding cod liver oil, the lack of antirachitic factor is the most plausible explanation of the conduct of this animal.

E-5 made fairly good gains for the first 220 days on experiment. His appetite declined then, and his growth rate slowed up. Throughout the experiment he at times exhibited stiffness

in walking. He developed a profuse nasal discharge early in the experiment, and this persisted through his whole career. At times this condition became exceedingly bad. On the 316th day he began to show signs of a general swelling in all four legs. It so happened at this time that the butterfat had been unavoidably left out of the ration for about one week. The addition of the butterfat made the ration more palatable and he began eating. Sixty-gram daily doses of marmite were administered and almost immediate improvement resulted. He became apparently normal in a few days, but when the butterfat was again intentionally left out of the ration for one week, with the marmite continued, he again refused to eat, became very emaciated, and lost 17 pounds in weight.

From time to time it had been observed that the feed would tend to take on a lardy or tallowy-like smell. This indicated oxidation of the butterfat which adhered to the feed particles as a thin film. It was then surmised that possibly the ration had been at times deficient in vitamin A and perhaps antirachitic factor. This is the most plausible explanation of the deportment of this animal.

On account of E-5 not being very thrifty when put on experiment it was decided at the end of a year to put him on a good grain and hay ration to determine whether he would be able to thrive under such treatment. He was able to do this, and on slaughtering him 30 days later, no abnormalities could be detected.

E-6 made consistent growth for about 1 year. The profuse nasal discharge gradually grew worse toward the close of her career. At 370 days on experiment she refused to eat and developed a severe form of scours. The butterfat had been left out of her ration also for about one week when she became very weak and emaciated. She was given 10-ounce daily doses of cod liver oil with the result that the scours disappeared and she made considerable improvement for about two weeks. Even with the cod liver oil continued she again declined. Sixty-gram daily doses of wheat germ extract brought no improvement. She gradually grew weaker, refused to eat, and finally died on the 416th day.

On post mortem, a large number of abscesses were found in the kidneys and right liver. This condition alone was enough to cause death. Abscesses were also found in the lungs which adhered to the ribs and diaphragm. There were a few other minor abnormalities in addition to a chronic catarrhal condition in the sinuses of the head which were filled with mucous and pus. The bones and joints showed no abnormal condition.

Vitamin A deficiency best explains the results with this animal also. Although the cod liver oil brought only temporary relief, it is reasonable to assume that the deficiency could have been the indirect cause of the abscesses, and that the condition had developed so far when the cod liver oil was administered that a cure could not be effected. Furthermore, Jones (6) found that cod liver oil effected cures very slowly when calves were suffering from vitamin A deficiency.

The evidence when summarized tends to indicate conclusively that vitamin A was insufficiently supplied to five of the six animals used in the preliminary experiments. The outstanding symptoms of calves suffering from vitamin A deficiency as recently reported by Jones (6) parallel in several cases those exhibited by the calves in these preliminary experiments. The following are outstanding examples: The blindness and severe scours of the Holstein animal S-3; the profuse nasal discharge exhibited by all the animals except B-10; severe scours in the case of E-6; loss of complete control of the legs exhibited by several of the animals; and oedema in the case of E-5 and E-6.

The results with one animal, B-10, that had received cod liver oil continuously contributed evidence that calves can maintain normal growth and well-being without a supply of vitamin B in the ration. The data on the five other animals is considered valueless except for the fact that it paved the way for a more closely controlled main experiment.

MAIN EXPERIMENTS, PART I

In planning a continuance of the investigation provision was made for conducting a series of parallel experiments on rats with the view of obtaining first hand information on the vitamin

B deficiency of the calf rations employed. It was the aim also to use at least twelve calves and to get them started on the experimental ration at the earliest possible age. The use of heifer calves only was planned for the advantages that might be afforded in making a later study on reproduction and lactation.

Ration. In order to insure an adequate supply of vitamin A, plans were made for feeding cod liver oil as a supplement to the

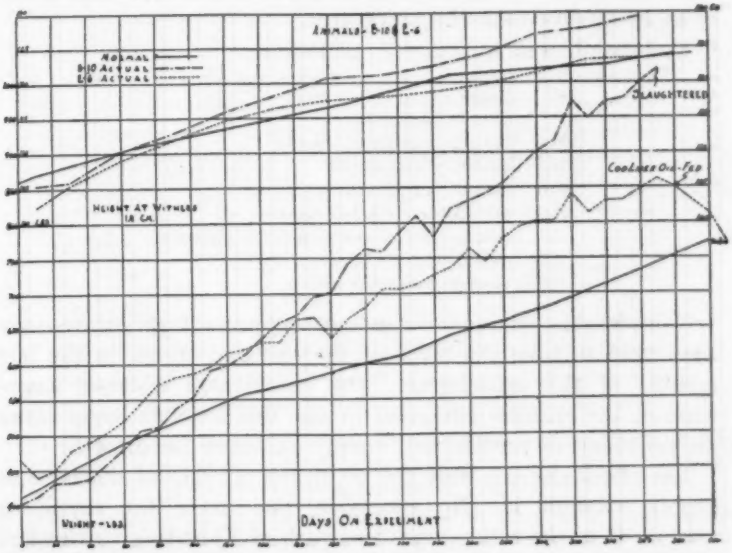

FIG. 1. GROWTH CHART ON TWO OF THE SIX ANIMALS USED IN THE PRELIMINARY EXPERIMENTS

Note the excellent growth made by B-10 on the vitamin B deficient ration supplemented with cod liver oil.

experimental ration. A high grade of medicinal oil was selected. It was kept in brown glass containers in cold storage, and provision was made for feeding it in fresh daily doses of 15 to 45 cc. per day, depending on the size and age of the calf.

Since the rations employed in the preliminary experiments were rather unpalatable to some of the calves, several changes were made to improve this defect. Imported dried beet pulp

(Holland) was found to provide a big improvement. It was cleaner than domestic pulp and was highly relished by the calves. The addition of cane sugar to the concentrate mixture made it possible to get further palatability by soaking the beet pulp and grain together for 12 hours before feeding. A high grade of casein put out by the Grove City, Pennsylvania, Creamery also provided further improvement in palatability. In the later months of the experiment, an imported product (Argentine) of equal quality took the place of it.

The ration was formulated as follows:

200	pounds corn gluten meal
100	pounds cane sugar
100	pounds commercial casein
62.5	pounds polished rice
62.5	pounds corn starch
24.0	pounds precipitated chalk
3.5	pounds mono-basic potassium phosphate
1.75	pounds ferric citrate
0.625	pounds potassium iodide.

Considerable amounts of pearled hominy from white corn were used to take the place of the rice and starch in the last months of the experiment. The ration was widened somewhat as the animals advanced in age, due account being taken for provision of protein and energy sufficient for growth.

The check animals were fed 40 grams per day of marmite to supply vitamin B. No provision was made for supplying vitamin C in the ration since the work of Thurston, Eckles and Palmer (7) had demonstrated this to be unnecessary. The cod liver oil carrying antirachitic factor in connection with the liberal mineral supply was assumed adequate for mineral requirements.

The amounts of feed consumed varied according to the size, age, and appetite of the calf. The minimum for young calves was about 1.5 pounds of concentrate and 2.5 pounds of beet pulp daily. The maximum amounts consumed daily by any animal when about 30 months of age was 5 pounds of concentrates and 10.5 pounds beet pulp.

Laboratory animal feeding tests. A series of eleven rat feeding

trials involving the use of 127 animals, fed individually in cages with screen bottoms (3 meshes to 1 inch), were conducted with the view of determining the vitamin B deficiency of the calf ration. In nine of the trials the calf ration was fed to young rats with certain modifications. It was not possible to feed beet pulp to an extent greater than 25 per cent of the total ration. On a 50 per cent beet pulp ration the rats would bloat and die in about one week. The scheme of feeding alco-

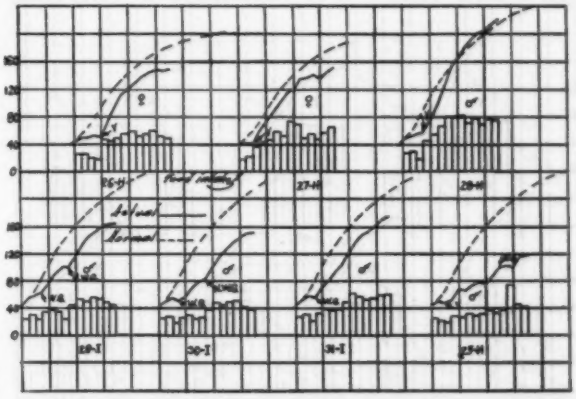

FIG. 2. FEED CONSUMPTION AND GROWTH BY WEIGHT OF RATS FED A RATION CONSISTING OF ALCOHOLIC EXTRACT OF BEET PULP, CALF GRAIN MIXTURE 75 PER CENT, AND AGAR 50 PER CENT

W. G. and N. W. G. indicate the addition of wheat germ extract to the ration, and Y. indicates the addition of yeast.

holic extract of beet pulp in amounts that would be equivalent to 50 per cent of beet pulp in the ration was resorted to in two trials.

In order to determine that beet pulp did not carry substances toxic to rats, two trials were conducted with pulp that had been subjected to extraction with alcohol. Two tests were made on the concentrate mixture alone. Agar and dextrin were supplemented to the extent of 5 per cent, and 20 per cent of the ration respectively in order to adjust the protein content and afford some bulk.

Very consistent results were obtained in all of these feeding trials. The calf ration, on account of vitamin B deficiency, would not support growth of the young rats for more than 2 to 4 weeks. This deficiency was proved through the feeding of wheat germ extract or yeast supplement which enabled the rats to recover, to thrive, and in many cases to attain normal size. A considerable number of controls gave conclusive evidence that the calf ration was nutritionally complete for the growth and well being of rats when it was supplemented with either yeast

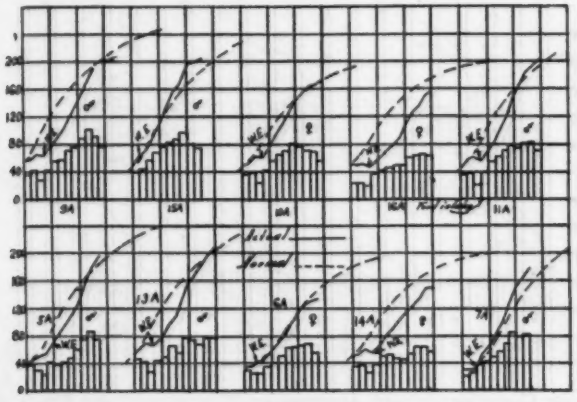

FIG. 3. FEED CONSUMPTION AND GROWTH BY WEIGHT OF RATS FED A RATION CONSISTING OF CALF GRAIN MIXTURE, 75 PER CENT; DEXTRIN, 20 PER CENT; AND AGAR, 5 PER CENT

W. E. indicates the feeding of wheat germ extract

or wheat germ extract. A graphic summary of two representative feeding trials is submitted in figures 2 and 3.

Pearled hominy was tested for its vitamin B potency through feeding it, one case as 25 per cent, and in another case as 50 per cent of a synthetic basal ration. The fact that the hominy was practically devoid of vitamin B is indicated in figure 4 which summarizes one of these feeding trials.

Experimental calves. Four grade Holstein female calves, numbers 1167, 1168, 1169, and 1170, and four purebred Holstein female calves, numbers 1176, 1175, 1182, and 1185 were

used. The grades were designated as group I and the purebreds as group II. The ages at the time of going on experiment varied between 112 and 179 days, the calves in group I being the younger. Calves 1167, 1168, and 1169 had been fed a small amount of milk and were considerably under normal size at the time of going on experiment. All others had received care and treatment corresponding to the practice of good dairy farms, and with the exception of 1185 were about normal in size when put on experiment. Number 1185 was more or less unthrifty

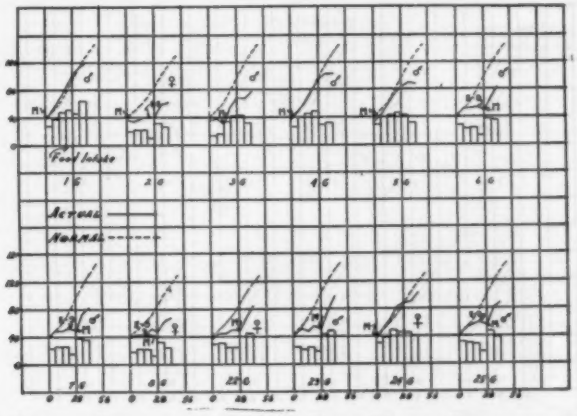

FIG. 4. GROWTH CURVES ON RATS FED A BASAL RATION CONTAINING 50 PER CENT OF PEARLED HOMINY

E. S. indicates the addition of wood shavings extract to the ration; M. the addition of marmite.

from birth. Numbers 1167, 1182, and 1185 were chosen as controls and were accordingly fed 30 grams daily doses of marmite in the ration.

Effect of vitamin B deficiency on the growth of calves

Figures 5, 6, 7, and 8 summarize in graphic form a record of the growth of the eight individuals in groups I and II. All of these heifers were continued on the experimental ration for periods ranging from 20 to over 140 days longer than the time indicated

on the charts. The growth rate portrayed on the charts was continued in every case.

The conduct of all the subjects was surprisingly uniform. They tended to eat sluggishly and thrive poorly for the first couple months. As a result, they were considerably under normal weight for the greater part of the first year on experiment. Even though Numbers 1167, 1168, 1169, and 1185, were handicapped in being below normal weight at the time of going on experiment, they, as well as the four other individ-

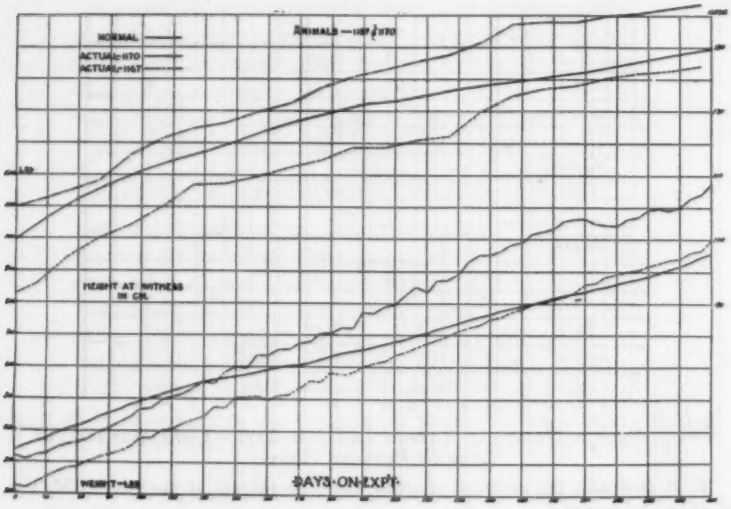

FIG. 5. GROWTH CURVES FOR 660 DAYS ON TWO CALVES FED THE RATION DEFICIENT IN VITAMIN B

uals, were able to overcome this handicap and to attain weights and heights at withers equal to or considerably greater than normal before they were two years of age.

At no time did any of the individuals exhibit any signs of vitamin B deficiency. The control animals gave no evidence of doing any better than the others, and the removal of marmite from their rations had no effect whatever on their growth or general well being.

The dried sugar beet pulp as the sole source of roughage appeared to be highly satisfactory for growth and general well being. The lack of bulk in the ration appeared to promote the habit of the calves to eat considerable wood shavings that was used for bedding and also to chew at the wooden partitions of their pens, especially in the earlier months of the experiment.

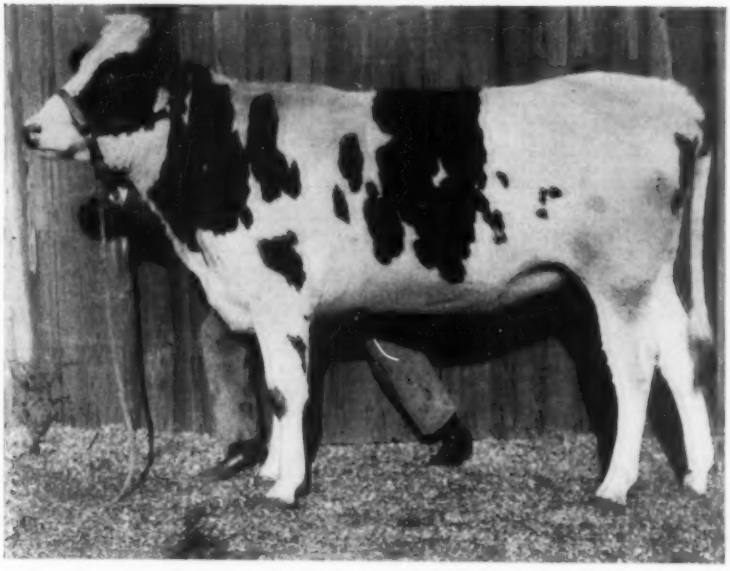

FIG. 6. ANIMAL 1170 AT THE AGE OF 27½ MONTHS WHEN ON EXPERIMENT 660 DAYS

Her weight, 1127.8 pounds, is 120 per cent normal and her height at withers is 105.7 per cent normal. She is a typical representative of the heifers in the main experiment when on the deficient ration 600 days or longer.

The fact that none of the animals ever ruminated was also another sign that the ration lacked bulk. The development of barrel in all cases appeared equal to that of heifers fed normal rations.

Four of the heifers when taken off the experiment and given a grain and hay ration began ruminating in about 24 hours after the change. It required about two weeks for them to come up

to a full feed of grain, hay, and silage. So far as can be determined, the feeding capacity was not injured by the experimental ration.

All of the heifers were bred and at the time of this writing (April, 1926) five of them have dropped strong, vigorous calves that are normal in every respect. Not a single animal failed to conceive. As they approached the time of parturition the mammary development became most excellent (see fig. 10).

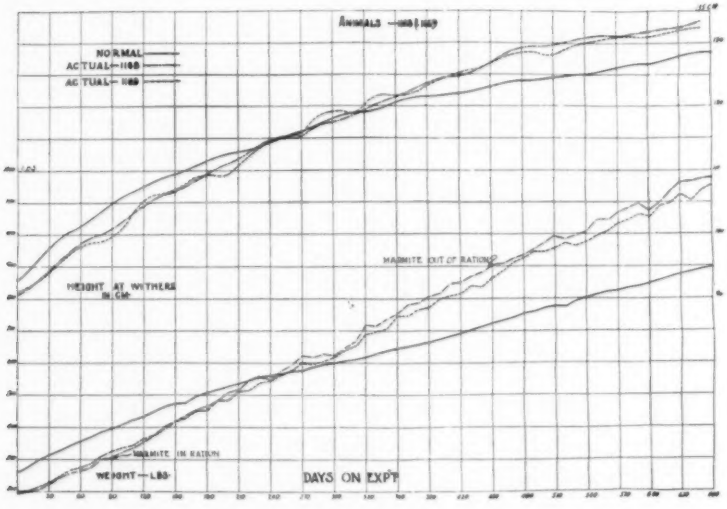

FIG. 7. GROWTH CHART FOR 660 DAYS ON TWO CALVES FED THE RATION DEFICIENT IN VITAMIN B

The marmite supplement in the ration of calf 1168 until the 445th day had no effect.

They were all very fat at this time, and their coats were quite sleek and glossy. The first three heifers to freshen, numbers 1168, 1169, and 1170 had considerable difficulty in calving and required assistance. This was perhaps due mostly to the fact that the calves were quite large, the birth weights being 107, 102, and 83 pounds respectively for the three heifers. They also had some difficulty with retained placentas, but finally cleared up satisfactorily in about one week.

They came back on full feed in a couple of days after freshening and then apparently went along in fine shape, the milk production being from 20 to 35 pounds per day. About the end of the second week of lactation they began going off feed. In about one week they refused to eat entirely. Sixty-gram daily doses of marmite given as a drench failed to bring any response. Drenches of 1½ pints cod liver oil and ½ pound of

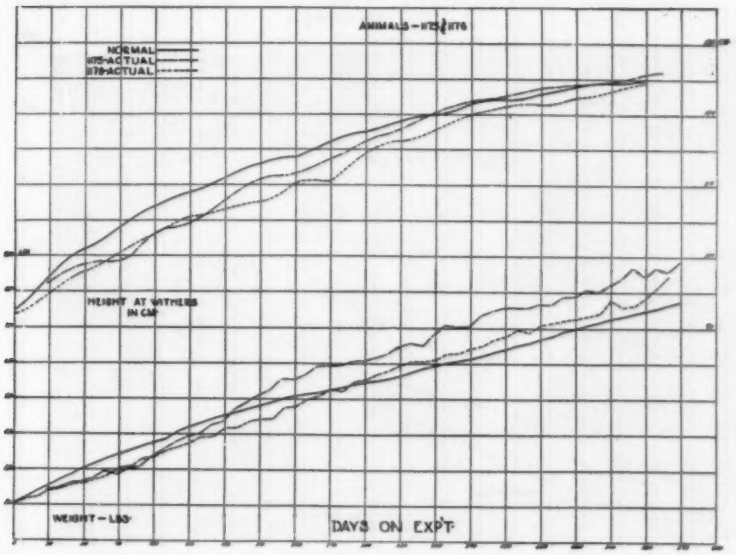

FIG. 8. GROWTH CHART ON TWO CALVES RECEIVING THE RATION DEFICIENT IN VITAMIN B

precipitated chalk was later tried with the same result. In the case of heifers 1170 and 1182 prevention of the difficulty was tried through feeding three times the usual amount of cod liver oil beginning about two weeks before freshening. Number 1182 was also fed 60-gram daily doses of marmite, but these heifers almost exactly duplicated the action of 1168 and 1169. The only difference observed was that 1182 delivered her calf unassisted and dropped her placenta promptly.

A subnormal temperature of about 1½ degrees was observed in all of them after they got entirely off feed. They became quite thin and weak, tended to get rather stiff, especially in their hind parts, and the milk production declined rapidly. The bowel movement ceased almost entirely. They consumed in some cases more than the usual amount of water and the urine flow was quite copious. There was a good deal to indicate that

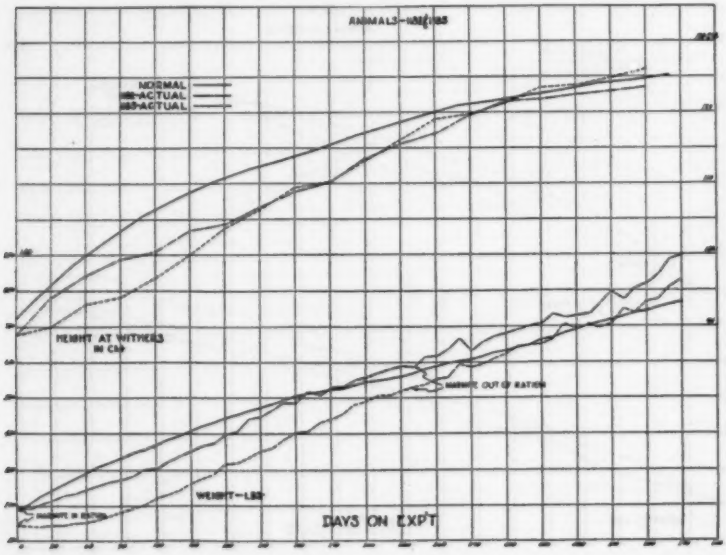

FIG. 9. TWO CALVES FED THE DEFICIENT RATION WITH MARMITE SUPPLEMENT FOR THE FIRST 340 DAYS

No stimulation of growth by the marmite could be observed, and when it was dropped from the ration the rate of growth was maintained.

the metabolic processes were quite low. It was with great difficulty that they were induced to eat small amounts of alfalfa, bran, oats, and oil meal, when these feeds were first offered to them. It was necessary to do some forced feeding with molasses dissolved in water. Once sufficient hay was eaten to start rumination, the appetite appeared to pick up rather rapidly.

That the difficulty is due to a mere lack of bulk or roughage in the ration, rather than to a mineral or vitamin deficiency, we are not in position to say. It appears that the trouble may be the same as that reported by Reed and Huffman (8), McCandlish (9) and other investigators (10).

The problem will be pursued on the other heifers due to freshen in the near future, and also on mature cows that are accustomed to dairy rations ordinarily fed.

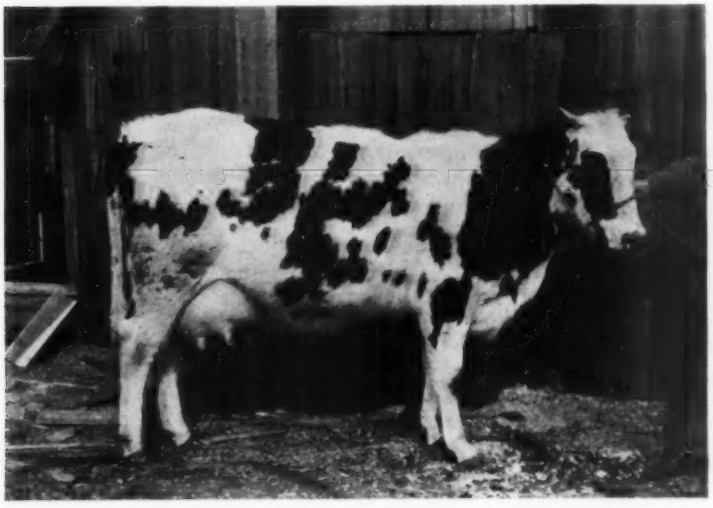

FIG. 10. ANIMAL 1182 THREE DAYS BEFORE SHE FRESHENED

She had been on experiment 690 days at this time, weighed 1180 pounds and her condition is representative of all the experimental heifers previous to freshening.

It had been the plan to raise the calves on their mother's milk until they could be weaned to the dry ration deficient in vitamin B. It was expected that the milk would be deficient in vitamin B and that the second generation could perhaps be grown up on a deficient ration. Unfortunately such was not possible. One calf was maintained on its mother's milk to the age of three weeks. It became quite vigorous and increased in weight

38 pounds in this time. In order to get definite information on the vitamin B potency of the milk, a large quantity was saved up and stored below freezing temperature before the heifers went off feed. Results of rat feeding trials with this milk, now in progress, will be published in a later paper.

MAIN EXPERIMENTS, PART II

The object of this experiment was to feed calves on a ration deficient in vitamin B from birth. The plan consisted in feeding cows due to freshen in several weeks on a ration deficient in vitamin B with the idea of continuing them on the same ration for a considerable period after freshening. Kennedy and Dutcher (11), McCollom, Simmonds, and Pitz (12), and Hughes, Fitch and Cave (13), have reported that vitamin B in milk is dependent on vitamin B in the diet.

In view of these data, it was assumed that the cows would produce milk, low in vitamin B, which could be fed to the calves until such time when they could be weaned over to the ration deficient in vitamin B which was described in part I.

Animals used. Two Jersey cows, 936 and 838, due to freshen in 6 weeks, and two Holsteins, 850 and 988, due to freshen in 10 weeks were used.

Care and feeding. Dried sugar beet pulp, the sole source of roughage, was fed with the following grain mixture:

200 pounds corn gluten meal
160 pounds pearled hominy from white corn
35 pounds tankage (60 per cent)
16 pounds special steam bone meal
2 pounds salt

All four cows ate the ration very satisfactorily at the start, and the Jerseys never got off feed until at or near freshening time. They were both brought back on feed by eliminating the tankage from the ration, but in about ten days after freshening 838 refused to eat entirely and finally had to be taken off the experiment. Cow 936 was in much better shape. She produced enough milk for both calves, 1222 and 1224, and did not

go off feed until about one week before the Holstein cows freshened. Every conceivable change of ration failed to bring her back on feed, and she died a few days later. The actions of these cows in refusing to eat after freshening were almost exactly like those of the heifers as described in part I. The one Jersey calf, 1224, was accidentally killed by the herd bull. The other, a heifer, 1222, was fed milk from the Holstein cows.

The Holstein cows resented the ration very much from the start. It was finally necessary to eliminate the tankage and

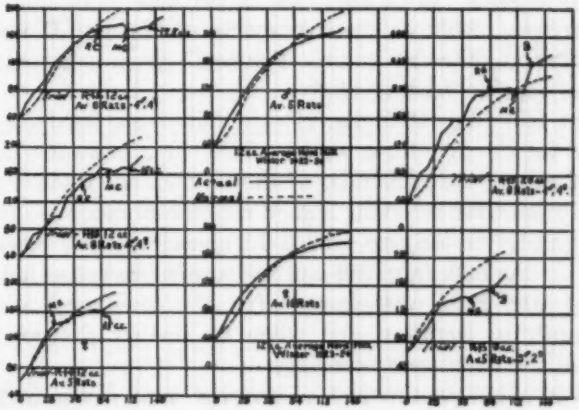

FIG. 11. GROWTH CURVES REPRESENTING AVERAGES OF GROUPS OF RATS IN MILK FEEDING TRIALS

R. D. indicates time of change of ration of cows 988 and 850; M. C., that milk was changed to that from cows receiving a good ration; 17.5 and 15 cc. that milk was increased to such amount; and B. that wheat germ extract was added to the ration.

bone meal. They lost considerable weight and were quite thin when they freshened. The calves, both heifers, were strong and vigorous, however. They were designated as 1230 and 1231.

About two weeks after freshening these cows went off feed just as the Jerseys had done. A change of ration was necessary to keep up the milk flow for the three calves. They were brought back on feed by supplementing the ration with oats and poor

quality, overripe, timothy hay which was three years old. The grain mixture from this time on consisted of two parts oats, one and one-half parts gluten meal, and one and one-half parts pearled hominy.

Rat feeding experiment. Five rat feeding trials were conducted for the purpose of determining the vitamin potency of the milk produced by the cows. The rats were confined in individual cages provided with screen floors (three meshes to one inch), and fed a basal ration consisting of 18 per cent purified casein, 3 per cent salts (McCollum 185), 2 per cent agar, and 77 per cent dextrin. Milk as the sole source of vitamin B was supplemented at different levels. Figure 11 gives a graphic summary of all five feeding trials.

In the first trial (R-12, fig. 11), the milk from the Jersey cows was fed for the first three weeks. Milk from cows 988 and 850 was fed during the remainder of the time except when a change to milk from cows receiving a good ration was made as indicated on the chart. In the next trial R-13, as well as in all subsequent trials only the milk from 988 and 850 was fed except as indicated. Feeding trial R-14 was started after the cows were advanced one month in lactation and when no further changes in the ration of the cows were necessary.

Twelve cubic centimeters of average herd milk had been about adequate for normal growth of rats in trials conducted in this laboratory during the previous winter. Two average curves of these data are included for convenience of study. These rats did not drop below the normal growth line until on experiment nearly 84 days, whereas those in experiments R-11, R-12, and R-13 dropped under the normal growth line somewhat earlier. Furthermore, at the end of 112 days they were considerably smaller than those fed normal herd milk for the same period of time.

The growth curve of the group R-15, fed 20 cc. made gains greater than normal and thus gave some indication that the milk was very little deficient in vitamin B. The group R-16, that received 8 cubic centimeters gave every indication of inadequate vitamin B supply, especially when wheat germ extract was supplied.

Although the data do not warrant strong conclusions, they indicate that it is possible to reduce the vitamin B content of cow's milk to some extent through feeding a poor ration. Although in agreement with data of Kennedy and Dutcher (11) the results are not nearly so outstanding as these investigators were able to obtain. Hart (13) has recently expressed an

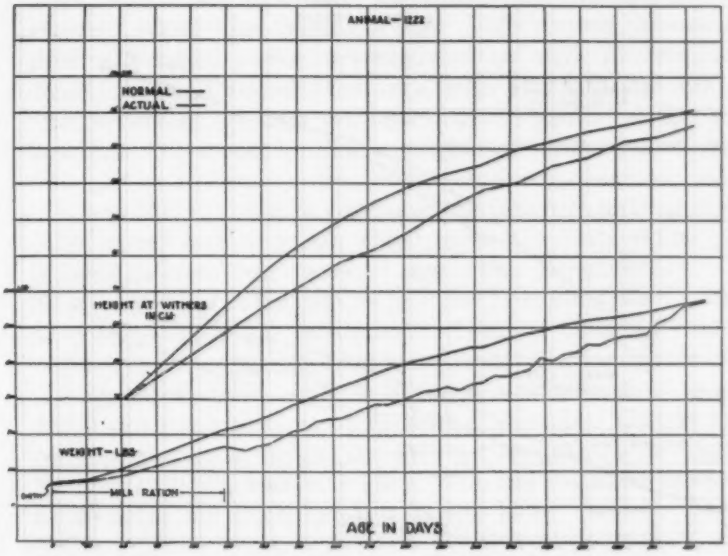

FIG. 12. EFFECT OF RATION DEFICIENT IN VITAMIN B ON GROWTH OF JERSEY CALF

Milk from cows fed a deficient ration was the main constituent of the calf ration for the first 147 days.

opinion out of harmony with our data. In commenting on grass versus winter feeding, he says that "Vitamin B is not very abundant in milk and is not influenced by the two types of feeding."

Effect of feeding calves a ration deficient in vitamin B

The three calves, 1222, 1230, and 1231, designated as group III, were fed on whole milk from the Holstein cows as their

sole ration until about 8 weeks of age. At this time they began eating the experimental concentrate mixture deficient in vitamin B and some dried beet pulp. The milk was discontinued as indicated on the growth charts (figs. 12 and 13) and the experimental ration was then fed after the methods outlined in part I.

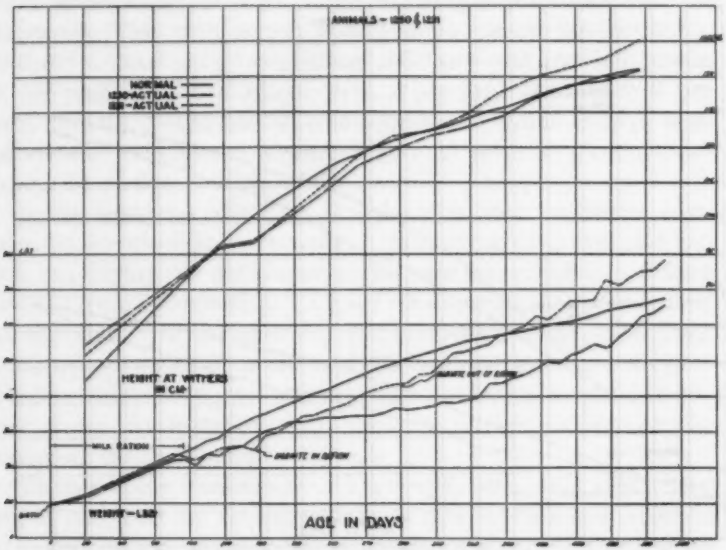

FIG. 13. EFFECT OF RATION DEFICIENT IN VITAMIN B ON GROWTH OF HOLSTEIN CALVES

Milk from cows fed a deficient ration was the main constituent of the calf ration for the first 115 days.

It is admitted that the practice of keeping calves on a ration which was made up almost solely of whole milk for so long a time was questionable, but no better plan seemed possible. It was our desire to bring them through if possible without the usual hay and cereal grain supplements until such time when they could get along on the experimental ration that was being fed to the older calves reported in part I. It was our feeling

that if this plan could be carried out, these three subjects would be superior to the older ones for a further vitamin B study.

They could not be induced to eat the experimental ration in sufficient quantities to warrant taking the milk away from them, and it was exceedingly difficult to get them weaned and going on the experimental concentrate and beet pulp ration alone, even when the Jersey was almost five months, and the Holstein nearly four months of age. They thrived throughout their milk ration career and exhibited no signs of deficiency disease. The Holsteins were very little under normal size at four months of age, but the Jersey at five months of age was less than 80 per cent normal in weight and 95 per cent normal in height at withers.

Group III was able to overcome the serious handicap of its early career and to attain about normal growth before the individuals were two years of age. The deportment of the group corroborated that of groups I and II in every way. They have been kept on the experimental ration for over four months beyond the time reported on the growth charts, and at this writing (April, 1926), 1230 is 109.4 per cent normal in weight and 103.3 per cent normal in height. Number 1222 is 98.7 per cent normal in weight and 98.5 per cent normal in height. Number 1230 will freshen in June, 1926, and the other members of the group are due about four months later.

GENERAL DISCUSSION

The results on growth and reproduction observed with the eleven animals reported in the main experiment are considered conclusively negative, but this should not be interpreted to mean that calves do not have a vitamin B requirement for growth and well being. It does mean, however, that it is either a case of no requirement for the factor in the ration, or such a small one that it cannot be measured with laboratory animals.

In view of the recent evidence put forth by several investigators we venture the opinion that bacteriological synthesis of vitamin B in the digestive tract suggested by Theiler (2) accounts for the fact that our experimental animals were able

to thrive, grow to maturity, and to produce normal offspring on a ration practically devoid of vitamin B. Damon (15) has made an outstanding contribution in this field of bacteriological research. He has been able to prove that several acid fast organisms synthesized vitamin B when grown in vitamin B free media. The dried bacterial cells fed to the extent of 7.5 per cent of a basal ration deficient in vitamin B stimulated rapid and continuous growth in young rats that were in a state of nutritive decline. Kuroya and Hosoya (16) have reported positive results with a pure culture of B. coli, but Damon's work does not confirm this. Heller, McElroy, and Garlock, (17) have produced evidence of bacteriological synthesis of vitamin B in the intestinal tract of the rat. Scheunert and Schieblich (18) have produced evidence of vitamin B synthesis by the organism B vulgatis commonly found in the intestinal tract of herbivora.

It is our plan, through the use of a fistula into the digestive tract of one or more of the remaining experimental heifers to obtain further light on the possible synthesis of vitamin B. This added phase of investigation in connection with the work now under way on the milk produced by the experimental heifers should give some light on the question.

Since dried sugar beet pulp was used as the sole source of roughage for all of the animals reported in this investigation, it is in order to comment on the so-called roughage requirement commonly mentioned in feeding practice. At this writing (April, 1926), nine of the calves, three of which have been on experiment since birth, have been maintained on the beet pulp ration for over two years. The barrel development has in every instance been apparently equal to that of calves fed on normal rations (see figs. 7 and 10). Evidence that the digestive tract was normally developed was obtained in a post-mortem on one animal, no. 1170. The rumen as well as other parts of the tract contained a large amount of food in the usual stages of digestion. The habit of eating considerable quantities of wood shavings, which were used as bedding, has continued with all of of the animals to the end of their careers. It is evident from this that the deficiency of bulk prompted the habit, even though,

reproduction, and general well-being were satisfactory. The absence of rumination in all of the animals throughout their careers was also likely due to the deficiency in bulk. These observations made it appear possible that the ruminating function could be effected by grinding hay and other roughages as advocated by certain manufacturers of feed grinders.

The inability of the heifers to lactate on the ration raises a question concerning the causation being due to a deficiency of roughage. Unfortunately, all experiments so far reported have dealt with calves. Reed and Huffman (8) have recently reported progress on rather extensive investigations. They have been unable to raise calves to maturity on milk alone, on milk and grain, or on grain alone. Calves fed solely on concentrates would die with convulsions and the post-mortem findings indicated toxemia. They attribute the toxemia condition probably due to a deficiency of a dietary factor rather than to crude fibre or bulk. Wheat straw, oat hulls, and wood shavings, did not prevent evidence of toxemia. Attempts to bring about normal development on milk rations without roughage were made through the feeding of calcium and phosphorus compounds. The results of these treatments prompted them to state that it is apparent that the irritability in calves fed on a concentrate ration is not due to a calcium or phosphorus deficiency.

Since our calves thrived so well through the growth period to maturity, it is evident that the beet pulp must have in some way supplied the deficiency encountered by Reed and Huffman. Our deficiency for lactation on the ration is probably the same or closely related to that observed by Reed and Huffman. If it is the same, the demands for lactation are evidently much heavier than for growth and reproduction. Since the present tendency in our high producing dairy herds is to supply nutrients more and more from concentrates rather than from roughage, the problem is of immense practical as well as of scientific importance.

Practical application of results

The average calf ration used in feeding practice is made up largely from leguminous hay and cereal grains. Since these feeds are usually classed as fair to good carriers of vitamin B, there is little likelihood of an ordinary calf ration being low in this vitamin. The present tendency toward raising calves with a minimum amount of milk would have scarcely no application since milk is, relatively speaking, not a heavy carrier of vitamin B.

Even though the fast growing tendency toward the feeding of by-products, especially of the milling industry, may eventually bring about the extensive use of rations which carry small amounts of vitamin B, the results of this experiment warrant the statement that the live stock man need have little concern about vitamin B deficiency ever standing in the way of his raising strong, healthy calves.

Furthermore, no evidence has been found to cause any fear, that the very serious problem of reproduction in our dairy herds will be further enhanced by vitamin B deficient rations.

CONCLUSIONS

1. An experimental calf ration composed of corn gluten meal, commercial casein, cane sugar, rice, pearled hominy, corn starch, dried sugar beet pulp, and a mineral mixture, carries an insufficient amount of vitamin B to support growth in rats and enable them to live for periods longer than 2 to 5 weeks.

2. A calf will grow normally to maturity and produce normal offspring on a ration that carries an insufficient amount of vitamin B to support growth and general well being in rats. Assuming that the calf possesses a physiological requirement for vitamin B similar to that of other animals, the deportment of the experimental calves described in this paper can be explained only on the basis of vitamin B synthesis by bacteria and other microörganisms in the digestive tract, unless future investigations should prove that various species of animals differ materially in their vitamin B requirements.

3. The milk produced by cows fed on a ration deficient in

vitamin B is appreciably, but not markedly, reduced in its vitamin B content.

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REFERENCES

(1) Eckles, C. H., Williams, V. M., Wilbur, J. W., Palmer, L. S., and Harshaw, H. M. 1924 Yeast as a supplementary feed for calves. Jour. Dairy Sci., vii, no. 5, 421.

(2) Eckles, C. H., and Williams, V. M. 1925 Yeast as a supplementary feed for lactating cows. Jour. Dairy Sci., viii, no. 2, 89.

(3) Theiler, A., Green, H. H., and Viljoen, P. R. 1925 Contribution to the study of deficiency disease. With special reference to the Lamziekte problem in South Africa. Third and Fourth Reports. Director of Veterinary Research. Dept. of Agriculture, Union of South Africa.

(4) Sherman, H. C., and Smith, L. L. 1922 The Vitamins, p. 91. The Chemical Catalogue Co., N. Y.

(5) Harshaw, H. M. 1922 The rôle of laboratory animals in determining the vitamin requirements of dairy calves. Thesis for the Degree of Master of Science, Graduate School, University of Minnesota.

(6) Jones, I. R., Eckles, C. H., and Palmer, L. S. 1926 The rôle of vitamin A in the nutrition of calves. Jour. Dairy Sci., ix, no. 2, 119.

(7) Thurston, L. M., Eckles, C. H., and Palmer, L. S. 1926 The rôle of the anti-scorbutic vitamin in the nutrition of calves. Jour. Dairy Sci., ix, no. 1, 37.

(8) REED, O. E., AND HUFFMAN, C. F. 1926 Feeding of concentrates to dairy cattle. Quarterly Bulletin, Mich. Expt. Station, viii, no. 3, 118.

(9) MCCANDLISH, A. C. Studies in the growth and nutrition of dairy calves.

MCCANDLISH, A. C. 1923 Milk as the sole ration for calves. Jour. Dairy Sci., vi, 54.

MCCANDLISH, A. C. 1923 The addition of hay and grain to a milk ration for calves. Jour. Dairy Sci., vi, 347.

MCCANDLISH, A. C. 1924 The addition of tomatoes to a milk ration. Jour. Dairy Sci., vii, 94.

(10) HENRY AND MORRISON 1923 Feeds and Feeding, 18th edition, p. 74.

(11) KENNEDY, C., AND DUTCHER, R. A. 1922 Influence of the diet of the cow upon the quantities of vitamins A and B in the milk. Jour. Biol. Chem., l, 339.

(12) MCCOLLOM, E. V., SIMMONDS, N., AND PITZ, W. 1916 The relation of the identified dietary factors, the fat soluble A, and water soluble B, of the diet, to the growth promoting properties of milk. Jour. Biol. Chem., xxvii, 33.

(13) HUGHES, J. S., FITCH, J. B., AND CAVE, H. W. 1921 The quantitative relation between the vitamin content of feed eaten and milk produced. Jour. Biol. Chem., xlvi, I, 1.

(14) HART, E. B. 1924 Vitamins in milk produced on grass versus winter feeding. Hoard's Dairyman, April 25, 1924, 565.

(15) DAMON, S. R. 1921 Bacteria as a source of water soluble B vitamin. Jour. Biol. Chem., xlviii, 379.

DAMON, S. R. 1923 Some observations in regard to growth promoting substances of bacterial origin. Jour. Biol. Chem., lvi, 895.

DAMON, S. R. 1924 Acid fast bacteria as a source of vitamin B. Jour. Pathol. and Bacteriol., xxvii, 163.

(16) KUROYA, M., AND HOSOYA, S. 1923 Tokyo Imp. University, Govt. Inst., Infect. Diseases. Sci. Reports 2, p. 287. Taken from Abs. in Expt. Station Rec., liii, 163.

(17) HELLER, V. G., MCELROY, C. H., AND GARLOCK, M. B. 1925 The effect of the bacterial flora on the biological test for vitamin B. Science, lxii, 139.

(18) SCHUENERT, A., AND SCHIEBLICH, M. 1923 Zur Kenntnis der Vitamine. Über die Bildung von Vitamin B durch Obligate Darmbakterien. Biochem. Zeit., cxxxix, 57.

A COMPARISON OF GUERNSEY SIRES

II. BASED ON THE AVERAGE MATURE EQUIVALENT FAT PRODUCTION OF DAUGHTERS DURING THE MONTH OF MAXIMUM PRODUCTION*

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The large probable number of genes or factors included in the inheritance of the characters concerned in the secretion of milk and fat by the dairy cow has resulted in little progress being made toward the genetic analysis of these important characters. Some of the more simple characters of cattle such as coat color, skin color, horns, and a few abnormalities have been studied genetically and have been found to behave in a Mendelian fashion. A few workers such as Wilson (1) and von Patow (2) have advanced theories as to the number of factors concerned in the inheritance of milk secretion. Wilson proposes that there are 4 dominant factors which individually produce 20, 15, 10, and 5 pounds of milk daily and collectively 50 pounds and 4 recessive factors which produce 4, 3, 2, and 1 pound of milk and collectively 10 pounds of milk. This being true there would be 16 grades of milk yield varying from 50 pounds daily down to 10 pounds.

While the theory is suggestive, it is believed that a larger number of factors are concerned and without more exact data than is yet available, the factorial analysis of the milk secreting function of the dairy cow is impossible.

A promising mode of attack of this problem appears to lie in a further study of the mechanism or mode of milk and fat secretion during the lactation period and to separate into groups those series of factors which may influence or regulate certain characteristics of the lactation curve of milk and fat secretion. In other words, instead of attempting to study single factors, a

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study would be made of groups of factors which together bring about certain results.

Sanders (3) has studied English Milk Records from the standpoint of the shape of the lactation curve. He has determined what is called the *shape figure* of the cow's lactation by determining the ratio of the total lactation yield to the maximum yield. This ratio is the same as the ratio which we consider to indicate the persistency of secretion during the lactation. This relation will be pointed out later in the discussion.

Considerable attention has been given to a study of the characteristics of the shape of the lactation curve at this Station. Studies have been made of some of the factors affecting the shape of the rising segment of the curve (4), the production at the maximum (4), and the declining segment of the curve (5). These investigations have indicated that of all the factors concerned in the lactation yield of fat two are outstanding in their influence.

The first of these is the height of production of milk and fat during the maximum month or other convenient unit of time. The second is the persistency of secretion or the rate of decline of production. These may later be further subdivided as knowledge of the mechanism of milk secretion increases.

Data has already been presented giving information on the mode of inheritance of yearly fat production in the Guernsey breed (6). It is the object of this paper to present similar data on the inheritance and mode of transmission of fat production during the month of maximum production using the same yearly records.

FAT PRODUCTION DURING MAXIMUM MONTH OF LACTATION PERIOD

Before considering the results of the study, it might be well to briefly consider the factors concerned in governing or limiting the maximum secretion of the dairy cow. The milk and fat which a cow is capable of secreting under favorable conditions of feeding and management in a given length of time is largely determined by two considerations. These are (1) the size of

the udder and the amount of secreting tissue present, and (2) the rate of secretion by a unit of secreting tissue. Do cows having the same amount of secreting tissue vary in their daily production of milk due to differences in the rate of secretion? Does the relation between the storage space and secreting tissue of the udder change the rate of secretion? Does the amount of blood passing through the gland influence the activity and rate of secretion? Is the size of the cow correlated with the size of the mammary gland or does the size of the animal influence production by increasing the capacity of the cow for feed consumption and greater blood supply or both?

The answers to these questions would greatly aid in clarifying the problem. While we do not have direct evidence by which the above questions may be answered a number of experiments have been conducted which furnish an indirect basis for making certain deductions. It has been shown by work at this Station that there is considerable variation in the activity of the mammary gland during a period of twenty-four hours as measured by the variation in the yield of milk during two-hour periods (7). This is believed to be due to the variation in the volume and nutrient content of the blood passing through the udder. It seems probable that mammary gland cells have an upper limit in their secretory activity which may vary among cows due to their inheritance with the result that certain cows although having equal secretory tissue would be able to produce more milk in a given interval.

It has been clearly shown also that the frequency of emptying the udder bears a close relation to its secretory activity (8). Does not this indicate that the amount of storage space in relation to secretory tissue would regulate or govern to some extent the rate of secretion. In other words, the inheritance of the size and internal structure of the udder would have a direct influence on the yield during the time of maximum milk flow.

Data is also available on the relation of the size of the cow to total yearly production (9). It was found that with animals of the same age an increase of 100 pounds in live weight produced an average increase of 20 pounds of fat per year. As

blood volume is correlated with live weight (about 5 pounds per 100 pounds), it is certain that more blood is available for milk production. That more blood actually passes through the gland, however, is not known. It would appear likely, however, in view of the greater production unless body size is positively correlated with udder size. This data indicates the extent of the influence of size inheritance on total yearly fat secretion. A greater proportionate relation to maximum fat secretion would undoubtedly be shown by live weight. Size inheritance must, therefore, be considered in its relation to maximum fat secretion. It is believed that the number of genes concerned in size inheritance must be considered as a part of the total inheritance for fat production and not as certain workers evidently believed that the inheritance of milk and fat secretion is confined to the stimulus for secretion (10).

Maximum secretion is the resultant of many anatomical and physiological relationships. Summed up they consist of gradations of size of the mammary gland both of secretory tissue and storage space, size of the digestive organs which furnish nutrients for the blood, size of the body in general which may be indicated by blood volume, and a stimulus to rapid production of the secretion. The variation in this stimulus probably will best be shown by the correlation between the summation of these size factors and maximum production. A high degree of correlation between the physical conformation of the dairy cow usually associated with large production and the yield of milk and fat will indicate that the rate of secretion in unit time does not vary greatly; a low degree of correlation will indicate that the rate of secretion is of considerable importance in relation to maximum production. Little hope of finding a close relationship between the type or conformation of the dairy cow and her production may be expected if the latter is true.

PERSISTENCY OF PRODUCTION

The declining segment of the lactation curve varies greatly in cows; some cows decline only slightly in production from month to month while others decline rapidly going dry at an

early date. In contrast to the physical characters of the dairy cow's anatomy which are associated with maximum secretion, is this intangible stimulus (similar to the possible stimulus for rapid secretion) persistency of secretion or the rate of decline of production during the lactation period. There is little in a cow's appearance to indicate whether she will decline rapidly in milk flow and soon become dry, or will decline very slowly in milk production and at the close of the normal lactation period still be producing a large flow of milk.

Possibly what the judge of cattle would call "dairy temperament" is the best external indication of the persistency of production of the cow. A lean, angular condition of flesh, however, may be a result of lack of feed, rather than due to the stimulation "to put everything into the milk pail." A cow which has been well fed and yet at the close of the lactation period is in low condition might be considered to be of the persistent type. In general, however, it may be said that the factor of persistency of production although of great importance in governing total yearly lactation milk yield, has no physical basis by which the extent of the stimulation may be determined.

The importance of persistency of production in relation to total production has not been generally realized. This has been due largely to the difficulty of securing a quantitative index of persistency. Recently the writer described a simple method of determining persistency from the ratio of the total yearly production to the maximum month's production (11). This ratio may be converted to a percentage basis indicating the average monthly decline in milk or fat production based on the preceding month's production. This gives a quantitative numerical expression for the important characteristic of milk secretion—the stimulation for persistent production.

In this paper especial attention will be given to the inheritance of the characters which are concerned with maximum production. The mode of inheritance of the stimulus for persistent production will be discussed in a paper to follow.

The change in production with age was corrected by the use of the conversion factors given in the Missouri Agricultural

Experiment Station Research Bulletin 79. As these factors were computed from the change in yearly production with age, there may be a slight error introduced as persistency of secretion changes slightly with ages. The error involved, however, is not sufficiently large to warrant redetermining this relation for maximum production and age.

COMPARISON OF GUERNSEY SIRES ON BASIS OF DAUGHTERS AVERAGE PRODUCTION DURING THE MAXIMUM MONTH

The purpose of the comparison of the sires on the basis of their daughters average production during the maximum month's production of the lactation period is designed to show the independence of the inheritance of the characters concerned with maximum production. Large production during the maximum month of the lactation period does not necessarily indicate high total production because of the factor of persistency. On the other hand, a combination of high maximum production associated with persistent production will always result in maximum yearly production.

In table 1 are listed the sires in order of the average fat production of their daughters during their maximum months production of fat compared with similar data for the dams of the daughters. This may be compared with the total yearly production of the dams and daughters. The persistency ratio (relation of total yearly fat production to the maximum month's fat production) is also given. The greater the numerical value of the ratio, the greater is the persistency indicated.[1] The differences in these two characters, maximum and persistent production, between the dams and daughters should be noted.

Might not the favorable combination of the genes concerned in the inheritance of the characters for maximum and persistent production in certain individuals causing greater producing ability than either family previously possessed, be produced in this way. While there is an occasional fortunate "nicking"

[1] A complete discussion of the quantitative determination of persistency of production indicating the meaning of the numerical values of the ratios may be found in reference 11.

TABLE 1

Comparison of Guernsey sires based on the average mature equivalent fat production of daughters during the month of maximum production

Maximum of Daughters

NAME AND NUMBER OF SIRE	DAUGHTERS				DAMS			
	Number of yearly records, daughters	Average mature equivalent fat	Average mature equivalent, month of maximum	Total / Maximum	Number of yearly records, dams	Average mature equivalent fat	Average mature equivalent, month of maximum	Total / Maximum
King Masher 11048	23	665	75.0	8.739	16	593	62.9	9.585
King Bell 13482	10	707	75.0	9.501	8	581	59.8	9.908
Lavanton 11611	10	729	74.6	9.873	10	690	73.8	9.375
Ne Plus Ultra 4th 29328	23	707	74.3	9.565	12	576	59.5	9.730
Bell-Founder 11681	19	694	70.7	9.776	10	643	66.8	9.763
King of Chilmark 20798	24	689	70.6	9.657	7	612	66.2	9.196
Langwater Stars and Stripes 21872	14	708	70.5	10.185	10	559	56.2	9.875
Ne Plus Ultra 15265	46	687	70.3	9.755	32	569	59.7	9.551
Golden Secret of Lilyvale 10028	23	674	70.3	9.645	16	592	64.6	9.201
Langwater Holliston 28055	10	726	70.3	10.322	6	583	60.9	9.542
King of the May 9001	33	708	69.8	10.125	25	625	64.4	9.664
Mars of Woodcrest 9290	10	563	69.7	8.070	4	459	57.6	7.934
King's Vanguard 22719	13	627	69.7	9.021	11	639	62.4	8.486
Florham Laddie 20431	30	662	69.6	9.314	11	592	62.5	9.492
Langwater Warrior 26509	23	701	69.3	10.044	18	764	76.7	9.941
Valentine Honour of the Passee G 3784	13	640	68.8	9.789	1	695	70.0	9.937
Lady Smith's Cherub 30760	12	688	68.6	10.154	10	614	65.1	9.423
Brookmead's White Face 32211	17	716	67.7	10.814	13	499	53.1	9.465
Holden IV 12179	12	621	67.6	9.838	7	689	74.1	9.314
Joker of Riverside 21447	10	595	67.5	8.796	4	558	62.8	8.887
Ledyard Bay 11074	10	645	67.2	9.625	9	498	48.5	10.106
Langwater Hayes Rosie's King of the May 16723	27	681	67.0	10.135	22	602	64.1	9.382
Langwater Royal 14253	27	616	66.8	9.107	22	554	62.2	8.889
Langwater Pencoyd 21830	18	658	66.8	9.837	16	679	69.4	9.757
Reputation of Portage 10695	11	632	66.6	9.642	5	584	68.2	8.973
Langwater Cavalier 21012	21	705	66.5	10.528	10	606	70.8	8.575
Ultra May King 27600	17	707	66.5	10.611	15	616	63.2	9.721
Charmante's Rose King 11746	11	624	66.0	9.442	7	632	57.4	9.334
Dairymaid's Criterion of Iowa 28187	12	598	65.9	9.160	6	523	57.9	9.228
Demonstration of Roughwood 23133	15	624	65.6	9.388	7	561	66.3	8.567
Gold Lassie's Jullian 27704	18	674	65.5	9.734	18	624	68.6	9.275

TABLE 1—*Continued*

NAME AND NUMBER OF SIRE	DAUGHTERS				DAMS			
	Number of yearly records, daughters	Average mature equivalent fat	Average mature equivalent, month of maximum	Total / Maximum	Number of yearly records, dams	Average mature equivalent fat	Average mature equivalent, month of maximum	Total / Maximum
Dolly Dimple's May King of Langwater 12997	10	630	65.3	9.630	9	626	63.1	9.682
Governor I. of the Chene 10563	24	639	65.2	9.811	12	671	68.0	9.856
Glenwood's Main Stay 16th 9384	10	597	64.9	9.313	6	486	51.1	9.154
Jardiniere's Masher 20957	14	668	64.7	10.248	11	655	66.6	9.844
Masher's Galore 8572	22	615	64.4	9.551	15	470	50.9	9.320
Rosie's Golden King of Oakhurst 31630	10	639	64.4	10.208	9	615	60.1	10.248
Golden Noble II G1836	29	590	64.3	9.241	3	447	56.1	7.980
Lord Waukesha 10148	18	575	64.3	9.056	14	522	59.1	8.881
Itchen Daisy's May King of Langwater 17349	24	637	64.2	9.829	18	530	56.0	9.486
Rex of Rich Neck 31472	15	645	64.1	10.119	13	669	65.2	10.241
Brockton of the Glen 15739	10	667	64.1	10.032	7	623	62.4	9.986
Golden Hero of L'Etiennerie 12647	16	553	64.0	8.698	5	461	59.5	7.899
Jessy Rosie's Pride of Iowa 3955	19	519	63.9	9.056	14	504	53.9	9.319
Laverna's Ultra May King 24660	12	585	63.8	9.667	7	565	65.6	9.463
Jethro's May King of Linda Vista 14591	15	620	63.6	9.420	15	615	62.9	9.843
Rinaldo 8917	11	601	63.6	9.474	11	639	65.2	9.844
May King's Vrangu of Ingleside 15430	37	634	63.6	9.877	30	611	63.2	9.584
Yeoman's King of the May 17053	84	610	63.5	9.487	64	508	58.3	8.850
Langwater Rival 14194	16	639	63.3	9.988	10	596	60.4	9.874
Pencoyd's Golden May Secret 39626	14	627	63.2	10.016	13	569	57.7	9.934
Jewel's Royal Combination of Wawa 15655	11	589	63.2	9.374	9	493	53.1	9.413
Beda's May King 11893	41	640	63.1	9.950	31	592	60.3	9.748
Sailor Lad of the Fontaines 51090	17	605	63.1	9.395	2	599	62.1	9.803
Honoria's Sequel II 40668	16	568	63.1	9.093	2	580	55.9	10.394
Victor of Pencoyd 18901	18	575	62.9	9.360	16	546	54.1	10.123
Pretoria's King of Midlothian 22641	10	601	62.8	9.705	10	569	68.7	8.516
Bob Rilma's Monogram 29095	10	608	62.8	9.653	10	523	59.5	8.872
Masher of Sarnia 19167	11	541	62.6	8.730	3	564	60.3	9.376
Hayes Cherub 2d 25147	16	630	62.5	10.047	9	595	65.2	9.371
Reservation Chesterfield 36609	13	634	62.5	10.106	12	556	58.8	9.529
Don Diavola of Linda Vista 23565	11	635	62.5	9.878	8	584	59.5	9.808

TABLE 1—*Continued*

NAME AND NUMBER OF SIRE	DAUGHTERS				DAMS			
	Number of yearly records, daughters	Average mature equivalent fat	Average mature equivalent, month of maximum	Total Maximum	Number of yearly records, dams	Average mature equivalent fat	Average mature equivalent, month of maximum	Total Maximum
Langwater Peerless 19227	12	559	62.5	9.181	7	613	63.5	9.657
Cora's King of Bellevue 9779	11	569	62.5	9.114	3	494	83.6	7.804
Silver King of the Isle 14363	13	531	62.2	8.613	9	517	55.2	9.412
Spotswood Sequel 9686	30	532	62.1	9.160	17	502	55.5	9.133
Giltedge of Koshkonong Place 21989	21	538	61.9	8.913	20	487	52.7	9.169
Onoko of Maple Row 11522	10	537	61.8	9.014	8	533	58.8	9.162
May King of Linda Vista 17946	16	599	61.7	9.838	15	585	64.6	8.828
Border Raider 22243	30	618	61.6	9.980	28	566	69.7	9.483
Langwater Royal Master 23663	14	632	61.5	10.254	9	626	65.0	9.565
May Rose King 2d 13130	16	594	61.5	9.963	9	582	64.2	9.052
Florham Monarch 20771	10	575	61.5	9.172	9	599	66.9	8.894
Modena's Yeoman of Langwater 10764	15	553	61.4	9.050	2	642	71.9	8.941
Jewel's Independence 10324	10	626	61.2	10.782	6	553	57.2	9.642
Langwater Traveler 38325	15	678	61.0	8.676	11	529	65.3	10.009
Baubigny's Squire of Keewaydin 21834	11	577	60.9	9.476	10	578	68.8	8.408
Flora's Sequel of Vimiera 25905	20	572	60.8	9.397	1	526	60.7	8.662
Jethro Bass 11366	30	612	60.7	10.149	26	565	57.5	9.872
Sister's King 33653	11	562	60.7	9.236	4	423	52.9	8.195
Aimable of France 13739	10	552	60.7	9.076	5	496	54.6	8.762
Cherub's Winner 34180	14	575	60.6	9.417	11	491	59.0	8.324
Julian of Koshkonong Place 14409	10	598	60.6	9.905	8	548	58.9	9.515
Langwater May King 13001	20	590	60.5	9.731	16	592	60.8	9.724
Moss Raider 22155	15	536	60.5	8.853	9	483	54.0	8.980
Penwyn of Rosendale 11282	11	566	60.4	9.404	8	683	69.5	9.945
France's Jewel's Champion 17970	13	554	60.4	9.751	1	513	50.5	10.140
Marshal of France 9051	12	549	60.4	9.206	5	506	53.4	9.560
Frank Rose 26342	11	562	60.3	9.332	9	483	51.9	9.328
Rockingham 18120	10	578	60.2	9.565	6	540	56.8	9.674
Gay Lad Du Braye G2026	18	543	60.1	9.059	1	648	60.7	10.669
Florham Golden Lad 18119	12	571	60.1	9.525	7	747	71.1	10.496
Royal Governor of L'Etiennerie G1484	10	547	60.1	9.023	1	487	67.3	7.246
King of Medfield 15434	10	549	59.9	9.153	4	431	52.0	8.200
Glenwood's Main Stay 40th 28108	12	536	59.9	9.509	3	523	63.7	8.245
Spotswood Rival 8346	12	581	59.7	9.354	2	471	44.1	10.643
May King of Ingleside 12558	22	521	59.7	8.829	20	483	55.0	8.888

TABLE 1—*Continued*

NAME AND NUMBER OF SIRE	DAUGHTERS				DAMS			
	Number of yearly records, daughters	Average mature equivalent fat	Average mature equivalent, month of maximum	Total / Maximum	Number of yearly records, dams	Average mature equivalent fat	Average mature equivalent, month of maximum	Total / Maximum
Gay Boy of the Isle 16998	17	581	59.6	9.836	9	571	64.5	8.978
Casterilius of Nelsonville 18052	10	587	59.5	9.954	10	576	64.2	9.219
Don Bernando of Linda Vista 20617	11	629	59.3	10.660	7	527	56.6	9.430
May Rose King 8336	21	632	59.1	9.975	18	532	55.1	9.625
King Masher 8th 20973	11	595	59.1	10.046	9	537	56.5	9.519
Langwater Frederick 22268	17	553	59.0	9.076	12	592	61.4	9.694
Duke of Waumesit 13480	12	555	59.0	9.414	6	494	53.9	9.197
Bell Buoy of Linda Vista 19430	32	575	59.0	9.747	24	542	64.8	8.489
Glenwood's Reputation 7687	20	533	58.9	9.152	4	477	52.2	9.196
Langwater Golden Secret 26510	14	579	58.8	9.927	8	615	68.5	9.174
Buckthorn 4781	11	547	58.8	9.241	3	525	53.6	9.852
Marcia's Glenwood of Pinehurst 11560	10	545	58.7	9.365	6	514	54.8	9.480
Lord Mar 14359	30	558	58.6	9.543	5	669	81.9	8.184
Langwater Hambro 21011	27	551	58.5	9.605	23	482	53.1	9.226
Stranford's Glenwood of Pinehurst 13609	14	565	58.5	9.669	14	566	64.17	8.890
Beau Regal 13448	13	561	58.5	9.532	4	763	73.0	10.528
Ideal's Senator 14736	13	474	58.5	8.185	11	454	54.7	8.374
Starlight's Excelsior 7992	24	521	58.3	8.956	10	477	57.9	8.265
Pencoyd's Golden Secret 16550	14	538	58.3	9.474	10	612	63.7	9.668
Itchen May King of Stannox 34377	13	534	58.2	9.158	12	591	64.8	9.028
Robert's Criterion of Bellevue 26887	18	589	58.1	9.871	2	514	64.7	8.395
Triple Champion 13067	18	544	58.0	9.473	13	516	60.3	8.476
Dairymaid's Standard of Iowa 28946	12	541	58.0	8.816	11	533	58.2	9.272
Langwater Demonstrator 16451	66	611	57.9	9.865	46	515	55.4	9.392
Rutila's Gold Basis 5625	13	487	57.9	8.464	7	455	52.3	8.764
Begalore 10101	13	540	57.8	9.291	6	570	59.8	9.461
Langwater Frenchman 19226	28	537	57.7	9.172	24	542	58.6	9.261
Goldseeker of Anna Dean Farm 26106	18	547	57.7	9.479	10	726	70.6	10.047
Pretor 9316	14	524	57.6	9.211	4	519	56.1	9.198
Dimple Bloom 14369	10	557	57.4	9.637	2	584	60.1	9.679
Glenwood Boy of Haddon 4605	26	521	57.3	9.147	21	559	64.8	8.613
Barrington May King 19312	19	594	57.3	10.376	17	570	51.7	9.982
France's Masher 2d 7248	12	512	57.3	8.954	1	649	68.2	9.511

TABLE 1—*Continued*

NAME AND NUMBER OF SIRE	DAUGHTERS				DAMS			
	Number of yearly records, daughters	Average mature equivalent fat	Average mature equivalent, month of maximum	Total / Maximum	Number of yearly records, dams	Average mature equivalent fat	Average mature equivalent, month of maximum	Total / Maximum
Moonlight King of Anna Dean Farm 29586	13	543	57.2	9.615	5	438	57.8	7.325
Lehigh's Golden Emperor 15761	18	516	57.2	8.999	6	458	60.4	7.616
Endymion 8916	16	533	57.0	9.283	8	568	59.3	9.550
Sequel's Monogram 15649	30	543	56.9	9.526	11	460	56.2	8.878
Itchen May King 25174	20	574	56.9	10.108	17	599	63.5	9.484
Langwater Dictator 15668	11	513	56.9	9.062	9	421	49.6	8.387
Guiding Star 12423	15	486	56.9	8.632	11	579	65.1	8.914
Langwater Royal 7th 20632	18	588	56.9	9.976	6	455	54.6	8.629
Jury of Koshkonong Place 16793	24	497	56.8	8.833	16	451	49.4	9.180
May Rose Secret of Pencoyd 27844	14	549	56.6	9.668	9	593	62.0	9.656
Governor of the Vanquiedor 39925	20	508	56.6	9.284	2	483	60.1	8.036
Golden Secret 12599	15	529	56.5	9.218	7	507	57.5	8.978
Ivy's Emblem G3804	10	566	56.5	9.864	1	662	70.1	9.435
Galaxy's Sequel 16904	53	523	56.4	9.354	13	542	60.5	9.001
Raymond's Pioneer of Lewistown 19103	20	590	56.3	9.351	14	617	66.5	9.243
Rutila's Sheet Anchor 5701	11	505	56.2	8.984	4	472	51.8	9.046
Robina's Standard 7254	21	473	56.1	8.515	11	535	59.7	9.065
Golden Secret of Pencoyd 23462	22	536	56.1	9.561	22	587	58.1	9.924
Pride of Day 17126	14	529	56.0	9.515	8	540	59.0	9.142
General Bay 16177	11	506	56.0	9.372	10	621	65.0	9.708
Alderney Raymond 26357	29	516	56.0	9.244	2	640	64.8	9.891
Pencoyd Quaker Boy 35552	10	556	55.9	9.562	2	559	57.0	9.807
Yeoman's King Victor 22295	15	539	55.8	9.837	15	576	62.3	9.295
Governor of the Chene G1297	112	524	55.7	9.500	2	545	59.2	9.123
Spotswood Masher Sequel 9687	11	504	55.7	9.017	7	444	54.0	8.355
Uncle Jim 16740	17	540	55.7	9.896	15	574	61.2	9.242
Dean of the May 21815	20	526	55.7	9.135	14	547	57.8	9.556
Hope's May Rose of Maple Hill 35903	12	518	55.6	9.329	7	542	57.8	7.795
Langwater Islander 31329	10	530	55.6	9.658	7	502	57.5	8.732
Langwater Fisherman 21873	12	549	55.4	10.053	6	512	53.8	9.604
Princesse's Jewel 24877	31	515	55.3	9.343	3	550	57.1	9.652
Prince of Sarnia 22000	21	523	55.3	9.621	9	492	50.6	9.763
Beda's May Day 34995	10	546	55.3	8.946	7	593	68.2	8.702

TABLE 1—*Continued*

NAME AND NUMBER OF SIRE	DAUGHTERS				DAMS			
	Number of yearly records, daughters	Average mature equivalent fat	Average mature equivalent, month of maximum	Total / Maximum	Number of yearly records, dams	Average mature equivalent fat	Average mature equivalent, month of maximum	Total / Maximum
Langwater Raritan 17052	17	566	55.2	9.632	17	499	52.7	9.423
Duke of Mouilpied G2045	11	523	55.2	9.450	1	408	48.8	8.340
Alderney II G2215	19	582	55.1	9.871	1	464	52.3	8.863
Jacqueminot of Linda Vista 23564	20	537	55.1	9.840	12	522	55.2	9.544
Masher's Sequel 11462	70	511	55.0	9.600	17	501	58.4	8.667
Glenwood's Stranford 9386	20	516	55.0	9.349	14	448	48.7	9.270
Robert's Boy 21662	13	520	55.0	9.277	3	568	64.0	8.710
Auricula's Main Sheet 8870	10	495	55.0	9.099	5	528	53.5	9.821
Glenwood's Combination 8th 12550	11	504	54.8	9.205	5	438	46.4	9.510
The Conqueror II 15323	17	542	54.7	9.929	4	504	53.8	9.276
Wolfram 5640	10	470	54.7	8.670	5	667	67.1	9.948
Lily Ella's Squire 6597	15	494	54.5	9.144	5	456	46.1	10.219
Selma's Main Stay's Son 23585	14	476	54.5	8.500	9	520	64.7	8.072
George Washington of Fairfield Farm 10866	12	516	54.5	9.459	3	548	60.8	9.051
Raymond of the Preel IV 19235	17	505	54.4	9.445	3	399	44.3	8.984
Itchen Red Raider 27342	10	549	54.3	10.517	8	634	62.7	9.909
Governor of the Cateret G3421	13	570	54.2	9.849	2	597	57.0	10.453
Allenwood King Regent 23611	13	562	54.2	10.354	13	508	52.9	9.697
Raymond of the Preel VI 14360	12	467	54.1	8.640	3	494	52.4	9.440
Dairymaid's Pride of Iowa 14941	12	518	53.9	9.596	5	601	68.7	9.095
Selma's Glenwood 12596	19	478	53.8	8.937	15	526	60.7	8.809
Souvenir of L'Etiennerie 21925	17	523	53.8	9.747	6	584	63.7	9.124
St. Austell Dreadnaught 34671	10	501	53.8	9.429	9	502	54.4	8.814
Skeezicks 9979	13	483	53.7	9.113	9	537	65.3	8.148
Sir Snowdoun 19252	20	496	53.5	9.104	17	431	47.6	9.094
Radium 9193	12	445	53.5	8.425	9	495	63.8	7.930
Frank Rilma 21901	11	520	53.5	9.732	8	485	50.2	9.794
Dairymaid's King 12898	21	490	53.4	9.200	18	438	54.8	8.113
Nelson II A52	12	497	53.4	9.452	1	476	54.8	8.861
Lord Mar V 18961	10	456	53.4	8.890	1	408	42.5	9.589
Strong Anchor 5849	15	491	53.2	9.296	3	441	45.8	9.608
Glenwood's Main Stay 6067	26	482	53.0	9.290	16	440	49.0	9.077
Lohier's Beta Raider of Waddington 35442	20	516	52.8	9.731	12	496	63.5	8.017

TABLE 1—*Concluded*

NAME AND NUMBER OF SIRE	DAUGHTERS				DAMS			
	Number of yearly records, daughters	Average mature equivalent fat	Average mature equivalent, month of maximum	Total / Maximum	Number of yearly records, dams	Average mature equivalent fat	Average mature equivalent, month of maximum	Total / Maximum
Dandy of Beirnetown 29963	17	523	52.7	9.742	16	512	48.2	9.685
Northern Boy G1779	11	448	52.7	9.268	1	621	72.5	8.558
Norfolk Squire 11565	14	504	52.6	9.584	6	506	56.1	9.055
Raymond of Blaye Farm A191	13	521	52.6	9.665	1	483	54.8	8.798
Dan Patch of the Isle 21293	11	517	52.6	9.850	11	511	65.6	9.251
Rhea's King of the May 14368	21	514	52.4	9.941	15	511	57.7	8.869
Barmouth of Pencoyd 11059	12	461	52.0	8.954	6	564	64.0	7.971
Glenwood's Son of Gayhead 19617	10	551	51.9	10.210	3	554	60.3	9.173
Christy of Pinehurst 31st 31984	10	479	51.6	9.177	5	419	48.8	8.577
Raymond of the Preel 11353	17	451	51.5	8.950	4	476	54.7	8.733
Christie's Combination 14651	10	475	51.2	9.389	9	427	46.2	9.370
Gypson's Count 8125	18	434	51.0	8.569	1	416	51.7	8.039
Roy of Norwood 8141	18	530	50.7	9.344	8	470	51.7	9.057
Raymond of the Preel II 13381	12	475	50.3	9.561	7	538	58.2	9.145
Fanny's Sequel 19563	28	478	49.9	9.428	7	574	61.1	9.459
Penwyn 2d 7559	10	400	49.5	8.213	5	428	58.1	7.462
Governor of the Gree 19123	15	500	49.3	10.150	2	519	58.2	8.908
Rouge II's Son 18587	10	471	49.3	9.592	9	462	53.6	8.756
Golden Anne's Fernwood of Homestead 11916	16	461	49.1	9.314	2	519	50.0	10.268
Malcolm of Maplehurst 5626	12	454	48.7	9.412	7	512	50.9	10.035
Capt. Robbie 7146	11	442	47.4	9.435	10	484	53.4	9.212
Preel VII's Champion Butter Boy 26132	13	425	46.2	8.960	12	448	47.2	9.573
Galaxy's Lavinius 12548	20	435	45.6	9.616	17	463	53.4	8.732
Ukiah 14344	14	405	45.1	9.174	14	447	48.5	9.282
Overture of Prospect 32821	10	456	45.1	10.067	6	395	41.6	9.686
Sunburst's King Maiden 37423	16	420	44.9	9.305	12	421	46.3	8.950
Coralette's Son 3987	12	399	44.9	8.976	11	421	51.9	8.167
Vaillant Coeur 7749	13	416	41.5	10.038	10	441	50.3	9.966

with resultant improvement, a much more certain plan of securing cows which possess these two characteristics to a high degree would be the use of sires having already demonstrated

through their daughters high maximum and persistent production. The next best plan would be the use of sons of such sires.

COMPARISON OF THE MAXIMUM PRODUCTION OF THE DAMS AND DAUGHTERS

As in the study of total yearly fat production, the relative effect of the sire and the dam on the daughters maximum production is of great interest. A summary of the results of the

TABLE 2

Dam and daughter comparison of Guernsey sires

DAM'S PRODUCTION OF FAT MAXIMUM MONTH (CLASS)	SIRE'S CLASS: DAUGHTER WITH MAXIMUM MONTHLY FAT 40 TO 44 POUNDS		SIRE'S CLASS: DAUGHTER WITH MAXIMUM MONTHLY FAT BETWEEN 45 AND 49 POUNDS		SIRE'S CLASS: DAUGHTER WITH MAXIMUM MONTHLY FAT BETWEEN 50 AND 54 POUNDS		SIRE'S CLASS DAUGHTERS MAXIMUM MONTHLY FAT BETWEEN 55 AND 59 POUNDS		SIRE'S CLASS DAUGHTERS MAXIMUM MONTHLY FAT BETWEEN 60 AND 64 POUNDS		SIRE'S CLASS DAUGHTERS MAXIMUM MONTHLY FAT BETWEEN 65 AND 69 POUNDS		SIRE'S CLASS DAUGHTERS MAXIMUM MONTHLY FAT BETWEEN 70 AND 75 POUNDS	
	Pairs	Daughters, average fat	Pairs	Daughters, average fat	Pairs	Daughters, average fat	Pairs	Daughters, average fat	Pairs	Daughters, average fat	Pairs	Daughters, average fat	Pairs	Daughters, average fat
		pounds		*pounds*		*pounds*		*pounds*		*pounds*		*pounds*		*pounds*
30–39	4	45.2	5	42.6	10	46.9	22	55.1	10	55.9	1	58.4	4	74.4
40–49	11	45.0	41	45.5	77	52.0	153	55.9	123	59.9	33	62.8	10	68.6
50–59	14	43.5	25	48.1	98	53.6	227	57.6	178	64.1	72	66.0	28	69.8
60–69	2	47.0	13	49.1	43	53.5	144	60.1	151	64.0	92	70.4	16	72.9
70–79			4	58.1	40	56.4	69	60.8	80	64.8	41	69.6	15	79.1
80–89					10	56.7	13	60.0	18	66.2	23	71.7	5	79.5
90–99					2	61.1	4	64.3	7	66.2	3	78.7	2	76.2
100–109					3	57.4	2	60.1	1	71.5	5	74.6		
110–119					—	—								
120–129					1	64.5								

dam and daughter comparison is shown in table 2. It will be noted that the sires are grouped into classes on the basis of their daughters' average maximum months' fat production. Then the average production of daughters by dams of varying productivity was determined. In order to determine the average influence of the dam on the daughters production, straight line equations most nearly fitting the observed values were calculated.

The equations are of the form $D = a + b\,d$ in which D is the average production of the daughters; d the production of the dam, b the constant increase in production of the daughters for each pound of increase in the production of the dams, and a the sire's potential transmitting ability with dams of such low production that they contribute nothing to the daughters.

CLASS OF SIRES (SIRE'S DAUGHTER'S MAXIMUM PRODUCTION)	CONSTANTS	
	a	b
70 to 75 pounds fat	52.2	0.34
65 to 69 pounds fat	52.1	0.25
60 to 64 pounds fat	52.4	0.17
55 to 59 pounds fat	50.1	0.14
50 to 54 pounds fat	43.8	0.16
45 to 49 pounds fat	36.2	0.21
40 to 44 pounds fat	38.3	0.15

The value obtained for b in each case indicates the contribution of the dams to the daughters inherited producing ability during the maximum month. The dam's contribution was found to vary from 15 to 34 per cent, being greatest in the groups of sires with daughters having the highest maximum. The average influence of the dams for all groups was 20 per cent. These results may be expressed in the form of the following equation.

$$\text{(1) Daughter's maximum fat production} = 0.20 \times \text{dam's maximum fat production} + \text{sire's potential transmitting ability}$$

$$\text{(2) Sire's potential transmitting ability} = \text{daughter's maximum fat production} - 0.20 \times \text{dam's maximum fat production}$$

These equations indicate that when using the dam's producing ability as an index of her transmitting ability and using a sire's daughter's average mature equivalent fat production as his index of transmitting ability that the former can be given only 20 per cent consideration. The second equation will be useful in determining the sire's potential transmitting ability when the daughter's and dam's production is known. In comparison

to the equations indicating the relation between dams, daughters and sires, it will be noted that the dam apparently contributes more to maximum production than to yearly production.

THEORETICAL DISCUSSION OF RESULTS

Can these results which are far from the results one might expect be reconciled with genetic and cytological facts? The following discussion is an attempt at such an explanation. If it is incomplete or faulty it will at least be a starting point for further experiments and discussion which in the end will result in an advance in our knowledge of the inheritance of the factors concerned in milk secretion.

The cytological facts in regard to the number of chromosomes carried by the egg and sperm in dairy cattle has been worked out by Wodsedalek (12). He has found that the female is the result of the union of an egg containing 19 chromosomes and a sperm containing 19 chromosomes. The male is the result of a union of a sperm containing 18 chromosomes and an egg containing 19 chromosomes. In other words, the female is homozygous and the male heterozygous for the sex chromosome. If the genes for large milk and fat secretion were carried on the sex chromosome (were sex-linked) it would be the female which would have the greater possibility in the transmission of the genes which influence milk and fat secretion. As it has already been shown that the sire can transmit his producing ability through his sons to his granddaughters to a high degree, even when he does not furnish a sex chromosome to his son, it is apparent that the genes concerned in the transmission of the characters for milk secretion do not lie on the sex chromosome and, therefore, are not sex-linked.

Due to the fact that the sire and dam contribute the same number of chromosomes to the female offspring, it has been assumed that the production of the daughters would be intermediate between the parents. This indeed has been found true for many characters which have been studied. In all cases studied, however, both the male and female exhibit the characters concerned. Milk secretion differing from such characters as size, etc., is

expressed only in the female sex. No direct measure of the sire's inheritance is possible.

While the female's production of milk and fat has been taken not only as the measure of her inheritance, but also of her transmitting ability, the male's measure of inheritance has been solely one of transmitting ability. In other words, an individual production test has been compared with a transmission or progeny performance test. It is this difference which has caused the sires to appear to contribute more to their daughers' producing ability than do the dams.

Why is a production test of the dam inferior to a progeny production test. The answer to that question can be found in Mendel's Law of inheritance. It has been found that plants and animals do not always breed on as they appear. Only the recessives always breed true to their appearance. The dominants are of two kinds, pure dominants and heterozygous dominants, only the former of the two kinds breeding true although in appearance are exactly similar to those heterozygous.

The theory is advanced that the factors which are concerned with the inheritance of large milk and fat secretion are in part at least dominant over the factors which produce a condition of limited secretion. The fact that dairy cattle do not breed true to their performance indicates that some, if not all, of the factors concerned in high production are dominants. The low producers maintain from generation to generation a yield of milk only sufficient to raise their calves.

Assuming that a large proportion of the factors for large production are dominant the experimental results obtained are easily explained. As already mentioned, it is believed that a large number of genes or factors are concerned in bringing about maximum secretion. The number and the relative contribution is a problem of the future. As it is difficult to deal with large numbers of factors, a trihybrid will be used as an illustration. Let us assume further that the dominants have a value of 30 pounds of fat and the recessives 5 pounds of fat, then:

Cow I of the composition AABBCC would produce 90 pounds of fat during the maximum month.

Cow II of the composition AaBbCc would produce 90 pounds of fat during the maximum month.

In segregation cow I would produce eggs of the following kinds:

ABC	ABC	ABC	Average 90.
90	90	90	

Cow II would produce eggs of the following kinds:

ABC	ABc	AbC	Abc	aBC	aBc	abC	abc	Average 52.5.
90	65	65	40	65	40	40	15	

Cow I being homozygous for 90 pounds of fat during her maximum month would contribute 90 pounds to all her progeny. Cow II being heterozygous although producing 90 pounds of fat would transmit only an average of 52.5 pounds of fat if all combinations were represented in her progeny. A single daughter might go as low as 15 pounds of fat or as high as 90 pounds of fat depending on the particular combination of genes which were received—the sires contribution not being considered.

The actual experimental results obtained indicate a high average degree of heterzygosity on the part of the females of the breed for the closer the approach to homozygosity the closer will the production records indicate the transmitting ability. This may be explanation why the dams maximum fat production is closer to her transmitting ability than her yearly record is an index of transmitting ability for yearly production.

The above illustration if applied to a sire indicates the value of a progeny performance test. Instead of using a single production test, the sire's ability is based on a group of daughters which tends to include all possible combinations of genes in segregation.

SUMMARY

1. Rather than to attempt a factorial analysis of the milk secreting function of the dairy cow, it is proposed that the characteristics of the lactation curve be studied in order to group together all factors which may affect certain parts and to study these characteristics from a genetic standpoint.

2. The two most important characteristics of the lactation curve of milk secretion are believed to be the height of production of milk and fat during the maximum month or other

convenient unit of time, and the persistency of secretion or the rate of decline of production.

3. A study was made of Guernsey Advanced Registry records to determine the relative effect of the sire and dam on the daughters maximum fat production.

4. The results were expressed by the two following equations:

$$\text{(1) Daughter's maximum fat production} = 0.20 \times \text{dam's maximum fat production} + \text{sire's potential transmitting ability}$$

$$\text{(2) Sire's potential transmitting ability} = \text{daughter's maximum fat production} - 0.20 \times \text{dam's maximum fat production}$$

5. The cytological studies indicate that the sire and dam contribute the same number of chromosomes to the female. The male is the result of the usual number of chromosomes from the dam and one less from the sire. This is taken to indicate that the above results can not be explained by sex-linked inheritance.

6. The results are believed to be explained by assuming that the majority of the genes concerned in the inheritance of large fat secretion are dominant over small secretion. Such being the case, the only true test of an animal's transmitting ability is a test of the progeny as compared to a performance record.

REFERENCES

(1) Wilson, James 1925 A theory of the mode of inheritance of milk yield in cattle. Jour. of the Dept. of Lands and Agr. Ireland, vol. xxv, no. 1.

(2) von Patow, Carl Freiheir 1925 Studien über die Vererbung der Milchergiebergkeit an Hand von fünfzigjährigen Probenselkaufzeichnungen. Zeitschrift fur Tierzuchtung und Züchtungsbiologie, Band IV, Heft 3.

(3) Sanders, H. G. 1923 The shape of the lactation curve. Jour. Agr. Sci., xiii, part 2.

(4) Turner, C. W., Ragsdale, A. C., and Brody, S. 1923 How the advance of the period of lactation affects the milk flow. Jour. Dairy Sci., vi, no. 6.

Brody, S., Turner, C. W., and Ragsdale, A. C. 1924. The relation between the initial rise and the subsequent decline of milk secretion following pasteurization. Jour. Gen. Phys., vi, no. 5.

(5) BRODY, S., RAGSDALE, A. C., AND TURNER, C. W. 1923 The rate of decline of milk secretion with the advance of the period of lactation. Jour. Gen. Phys., v, no. 4.

BRODY, S., RAGSDALE, A. C., AND TURNER, C. W. 1923 The effect of gestation on the rate of decline of milk secretion with the advance of the period of lactation. Jour. Gen. Phys., v, no. 6.

(6) TURNER, C. W. 1925 A comparison of Guernsey sires. Mo. Agr. Exp. Sta. Res. Bul. 79.

(7) Unpublished data.

(8) RAGSDALE, A. C., TURNER, C. W., AND BRODY, S. 1924 The rate of milk secretion as affected by an accumulation of milk in the mammary gland. Jour. Dairy Sci., vii, no. 3.

(9) TURNER, C. W., RAGSDALE, A. C., AND BRODY, S. 1924 The relation between age, weight, and fat production in dairy cows. Mo. Agr. Exp. Sta. Bul. 221.

(10) GRAVES, R. R. 1925 Dairy cattle breeding investigations. In Proceedings of the Scottish Cattle Breeding Conference.

(11) TURNER, C. W. 1926 A quantitative form of expressing persistency of milk and fat secretion. Jour. Dairy Sci , ix.

(12) WODSEDALEK, J. E. 1920 Studies on the cells of cattle with special reference to spermatogenesis, ōogonia, and sex-determination. Biol. Bul., xxxviii, 290.

SWEETENED CONDENSED MILK

VI. TALLOWINESS*

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There are, perhaps, more different and distinct flavors produced from the decomposition of milk fat than from any other fat or oil. While in other industries any abnormal flavor of fats is denoted as "rancidity," in the milk products industries attempts are made, particularly in recent years to distinguish between several different flavors, such as tallowiness, fishiness, rancidity, metallic and so on.

Tallowiness is a flavor remotely resembling tallow. It has been recognized in butter, powdered whole milk and raw milk. It is commonly accompanied by bleaching of the fat, and is generally attributed to the action of oxygen on the fat, the reaction being catalysed by light, ultraviolet light, metals, or free fatty acids (1). Mention was made of this defect in condensed milk in one of our previous papers (2), at which time it was pointed out that the flavor had been found to develop when unusual amounts of copper were present. The purpose of this paper is to present data in support of that statement, to contribute other information concerning the cause of this defect, and to discuss methods of prevention.

The flavor of tallowy condensed milk resembles to a considerable degree tallowy butter and powdered whole milk. It is a condition not so marked as that of rancidity or bacterial thickening. The acidity does not increase, neither does the viscosity. The odor and taste except in rare instances are very weak. Unless it is an extremely bad case the product may be used in baking and in candy making. In hot beverages the flavor is brought out to such an extent as to make it unusable. On opening a tin

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the sample appears sometimes but not always a little paler than normal. The tallowy flavor of the freshly opened sample remains even after exposure to the air for several days.

EXPERIMENTAL

Since it has been generally believed that tallowiness in other milk products is due to the oxidation of fat, a catalyst possibly being necessary for the reaction to take place, it seems fair to postulate that a similar reaction is involved in this case. Tins of condensed milk always include some air, and the product may contain a great deal of copper since so much of the condensing equipment is ordinarily constructed of that material. Light is eliminated as a factor here, since commercial samples are found only in tin; particular care was taken in this experimental work that samples in glass were kept in a dark place.

Oxygen as a factor in tallowiness production

It has often been noted in commercial samples, though this is not always the case, that it is only the layer of condensed milk at the top and exposed to the air space which is found tallowy. And this has been always the rule in experimental samples, unless care was taken to mix the liquid from time to time, in this way bringing fresh surfaces in contact with the air space. It has always been found in experimental samples that when tins or bottles were filled entirely full, there was less tallowiness, if any at all, than when a liberal air space remained above the liquid.

Experiment 1. To a sample of condensed whole milk was added 50 mgm. of copper in the form of copper lactate. The weighed amount of the salt was dissolved in a few cubic centimeter of water, added to the condensed milk, warmed to facilitate mixing, and stirred well with an egg-beater. This was divided into three parts each placed in a fruit jar so that the jar was only about three-fourths full. The air was displaced with oxygen gas in sample 1, and with carbon dioxide in sample 2; air filled the space in sample 3. The jars were well sealed to prevent escape of gas, and held in an ice storage room for later inspection.

Inspections for flavor were made at the end of twenty and forty days: At each time sample 2 was unchanged in flavor. Sample 1 was described as very tallowy at twenty days and extremely tallowy at forty days. Sample 3 was distinctly tallowy on both occasions but never becoming as strong as sample 1.

This experiment shows that oxygen is a necessary factor for the production of tallowiness in sweetened condensed milk.

Production of tallowiness a chemical not a biological change

In all the experiments here described the samples were held in an ice storage room until time of inspection. This procedure was adopted after several unsuccessful attempts to prevent growth of mold in other ways, it being impossible in the preparation of samples to prevent contamination. Due to the fact that condensed milk ordinarily becomes tallowy only after weeks or months, there is sufficient time for mold to develop and make it impossible to inspect the sample for tallowy flavor. It was found that the temperature of the ice storage room (27° to 32°F.) was such that mold growth was prevented while tallowiness developed just as rapidly as at room temperature. This is an indication that the reaction is due to the chemical oxidation of fat, and not to organisms or enzymes.

However, as was pointed out in the preceding paper of this series (3), it is possible that free fatty acids may catalyze the reaction involved in tallowiness formation. Fatty acids in milk products are derived most commonly from an enzyme hydrolysis of butter fat. In this way, therefore, enzymes may indirectly hasten tallowiness. This point of view might explain the findings of Palmer and Combs (4) where experiments bore indication that in butter a greater degree of tallowiness results when enzymes are present.

Other proofs of the statement that biological processes have nothing to do directly with tallowiness in condensed milk are the following:

1. Exposure of the product to very high temperatures for long periods of time did not lessen the effect, in fact it seemed that

when samples were exposed to a great deal of heat more tallowiness developed.

2. Bacterial counts on eight samples of tallowy condensed milk were—175, 220, 550, 770, 1050, 2570, 1690, 1400; the two which are lowest in bacterial counts happened to be strongest in the tallowy flavor.

3. At one time some samples to which had been added some copper for the purpose of obtaining tallowiness were divided and to one series was added 0.1 per cent mercuric chloride, to the other none. Later inspection showed that both series of samples became tallowy at equal rates.

TABLE 1

SAMPLE NUMBER	INSPECTION AT THE END OF			
	25 days	45 days	70 days	100 days
1	0	0	0	0
2	0	0	+	++
3	0	+	++	+++
4	++	+++	+++	+++
5	+++	+++	+++	+++
6	+++	+++	+++	+++
7	+++	+++		
8	0	0	+	++

Normal flavor, 0; tallowiness, distinct, +; tallowiness, fairly strong, ++; tallowiness, exceedingly strong, +++; blank spaces indicate that no inspection was made.

Copper as a factor in tallowiness production

Experiment 2. A quantity of freshly condensed milk was divided and treated as follows: Sample 1, no addition; sample 2, adding per kilo of product 2.5 mgm. of copper in the form of lactate; sample 3, 5 mgm.; sample 4, 10 mgm.; sample 5, 25 mgm.; sample 6, 50 mgm.; sample 7, 25 mgm. of copper as ammoniacal cupric oxide; sample 8, clean bright copper strips were introduced so that one end extended above the surface of the milk.

Several samples of each series were placed in sterile bottles,

leaving some air space. At each inspection a sample was used that had not been previously opened. Particular care was taken each time that the inspector did not know to which series the sample under consideration belonged until after judgment had been passed. Table 1 gives the results of inspection for tallowy flavor.

The speed of tallowiness production and the degree of flavor is seen to increase with the amount of copper present, an addition of as little as 2.5 mgm. per kilo being effective. In experiment 1 it was shown that oxygen is a necessary factor. It is concluded, therefore, that tallowiness is here caused by the action of oxygen on some constituent of the milk, the reaction being hastened by the presence of copper. (But this is not to exclude the possibility that other catalysts than copper may be effective.)

Five batches of condensed milk which were found to show varying degrees of tallowiness under most conditions were found to contain 3.9, 4.2, 5.7, 7.7, and 11 mgm. copper per kilo. Rice and Miscall (2) have reported finding in normal canned milk 2.4 to 4.8 mgm. copper per kilo with an average of 3.7 mgm. It would seem, therefore, that some batches of normal condensed milk might contain sufficient copper to cause tallowiness under suitable conditions, and this has been found to be the case. On several occasions condensed milk as canned in the factory and placed on the market did not become tallowy, while portions of the same batch held in fruit jars, leaving a liberal air space, did develop the flavor. Also in a few instances portions of condensed milk to which an excess of copper was added were filled into containers so that practically no air space remained, it was always found that tallowiness developed to a lesser degree than when more air remained in contact with the surface of the liquid. The conclusion to be reached from these experiments is that either oxygen or copper may may prove to be the limiting or controlling factor in tallowiness production.

Experiment 2 shows also that copper in other forms than lactate is effective. The metal in contact with condensed milk produces the tallowy flavor but slowly, due no doubt to the slowness with which it dissolves and diffuses in the milk. In another

experiment it was found that copper chloride and copper oxide caused tallowiness. The active factor is no doubt, therefore, the cation of these salts.

Tallowiness due to a decomposition of the fat

Since tallowiness has always been found in butter and separated butter fat as well as other fats, and since it has been noted in powdered whole milk but not in powdered skim, there seems little doubt that in those products the abnormal flavor is caused by a chemical change in the fat.

An attempt was made to obtain normal condensed skimmilk with no fat, but the nearest approach to it was a sample with 1.39

TABLE 2

SAMPLE	INSPECTION AT END OF	
	12 days	30 days
Skim, 40 mgm. copper per kilo	+	+
Skim, 20 mgm. copper per kilo	+	+
Skim, 0 mgm. copper per kilo	0	0
Whole, 40 mgm. copper per kilo	++++	++++
Whole, 20 mgm. copper per kilo	++	++
Whole, 0 mgm. copper per kilo	0	0

See table 1 for key to symbols.

per cent fat. This was compared with normal condensed whole milk with 8 per cent fat: To each was added 20 and 40 mgm. of copper in the form of lactate. The various portions were placed in fruit jars filling them about three-fourths full; the remaining space contained oxygen gas. Results of inspections are given in table 2.

Two other experiments gave results similar to those here shown. Condensed skimmilk may become slightly tallowy but to a very much less degree than condensed whole milk under the same conditions. Since, besides the fat, all other milk constituents are present in skimmilk in higher percentages than in whole milk, there is no doubt that tallowiness here is due to changes in the fat.

Exposure of condensed milk to air at the time of condensation

Since the action of air or oxygen with a catalyst will produce tallowiness during storage, it seemed possible that exposure to air during condensation might cause the same flavor defect, the catalyst not being necessary. Vacuum pans leak at the bottom quite frequently, thus permitting a flow of air through the milk during condensation.

For experimentation on this point provision was made for condensing in glass. A 3-liter flask was used in connection with a vacuum pump so that boiling would take place at 130° to 135°F. Batches containing 4 pounds of milk with the proper proportion of sugar could be thus handled.

Check batches prepared in this apparatus never became tallowy but when copper salts were present during condensation this flavor always developed.

A batch run while air was continually bubbled through the milk did not become tallowy. On other occasions portions of normal factory condensed milk were warmed to 135°F. and air bubbled through for one-half hour, and in other portions oxygen was whipped in with an egg beater. Tallowiness was not produced by these methods.

It is to be concluded that this flavor is not caused from the exposure of a batch to air or oxygen at the time of condensation.

Condition of factory equipment and its relation to tallowiness production

It has frequently been observed that after a vacuum pan has not been used for a considerable period of time the first batch run is almost sure to become tallowy. Analyses have shown also that the percentage of copper is unusually high in such a batch: One day's run in a factory on a pan which had not been previously used for several months produced condensed milk which when canned regularly into tins became strongly tallowy in thirty days. There was found 7.7 mgm. copper per kilo.

A 100-pound batch ran on a small (copper) experimental vacuum pan not used for two weeks previously became strongly tallowy, and was found to contain 11 mgm. copper per kilo.

It is common knowledge that the surface of the copper of unused pans and hot wells becomes covered with a black oxide coat, but when this equipment is in constant use the surfaces remain bright. Rice and Miscall (2) have shown that more copper is dissolved in milk from an oxidized copper surface than from one that is clean and bright. It must be concluded, therefore, that tallowiness in batches manufactured in equipment not previously used for some time is caused by the excessive amounts of copper dissolved from the surfaces.

Observations on some experimental batches prepared in glass with and without the addition of a piece of copper gauze fully corroborate these conclusions.

Effect of other metals on tallowiness

Aside from copper practically the only metals ordinarily coming in contact with milk in condensing equipment are tin and iron.

Experiments carried out with these metals in the same way that has been described with copper showed that tin does not catalyze the reaction at all. The action of iron was generally found positive but weak: For instance, in one experiment 25 mgm. per kilo of iron in the form of tartrate was added to a quantity of normal condensed milk, when frequent inspection showed that faint tallowiness developed only at one hundred twenty-five days. Under the same conditions 25 mgm. of copper produce extreme tallowiness in less than twenty-five days.

Tin and iron cannot be important in the production of the tallowy flavor in condensed milk.

SUMMARY

1. Tallowy condensed milk is produced through the action of the oxygen of the air in the container on the butter fat of the milk, the reaction being catalyzed ordinarily by small amounts of copper.

2. Tallowiness develops below 32°F. apparently just as rapidly as at room temperature; heat sterilization of the product does not prevent it; the bacterial counts of tallowy samples are low; addition of strong preservatives do not prevent the development

of the flavor. All these points are taken as proof that the reaction involved is chemical and that biological agencies have nothing to do with it.

3. Pure oxygen was found to be more active in producing tallowiness than air. The development of the flavor could be prevented by displacing the air with carbon dioxide, or, by filling containers so full that no air space remained. Tallowiness increases, therefore, with the extent of exposure to oxygen.

4. Tallowiness was found to increase with the amount of copper present. When the percentage of copper is small, much more oxygen or air space must be in contact with the sample to produce the flavor. And when there is but little air space more copper must be present.

5. Condensed skimmilk may become slightly tallowy if it contains any fat at all, which it usually does in commercial practice.

6. Copper condensing pans and hot wells that have not been used for some time previously yield an excessive amount of copper to the first few batches manufactured; accordingly, these batches are most likely to become tallowy.

7. Tin was found not to catalyze the tallowiness reaction. Iron was found to do so but to a very much less degree than copper; it cannot be important in practice.

Practical conclusions

1. To prevent tallowiness the air space in the cans and the copper in the milk should be reduced to a minimum.

2. Since open pasteurizers, holding tanks and hot wells may, if made of copper, yield more copper to the milk than vacuum pans (2), particular care should be taken that the milk does not remain in any of these articles of equipment longer than necessary. Wherever possible all copper equipment should be replaced by other materials for the manufacture of sweetened condensed whole milk.

3. In experimental and laboratory samples tallowiness developed only at the surface of the milk in contact with the air, but in samples obtained on the market this flavor may be found throughout the can. This is attributed to the fact that in ship-

ping and handling, the contents of the cans are so mixed that a new surface is frequently brought into contact with the air.

4. After a copper pan or hot well has not been used for a long time, particular care should be taken to clean the surface so that a minimum of copper will dissolve in the first batch. In the experimental work no method of cleaning was found which would entirely prevent tallowiness from developing in the first few batches run. It is therefore concluded that such batches should be put on a quick market or used in ice cream or candy manufacture.

REFERENCES

(1) Lidow: Vyestnik. Shirov. Vesheh., iv, 1903, 151; Experiment Station Record, xv, 606.
Hunziker and Hosman: Jour. Dairy Sci., i, 1917, 320.
Palmer and Combs: Jour. Dairy Sci., ii, 1919, 444.
Zilva: Biochem. Jour., xiii, 1919, 164.
Holm and Greenbank: Proceedings Society Biol. and Medicine, xx, 1922, 176.
Bitting: Glass Industry, iii, 1922, 157.
Tillmans and Strohecker: Z. Nahr. Genussm., xlvii, 1924, 377.
Greenbank and Holm: Jour. Ind. Eng. Chem., xvi, 1924, 598.
Hepburn: Jour. Franklin Inst., clxviii, 1909, 447.
(2) Rice and Miscall: Jour. Dairy Sci., vi, 1923, 261.
(3) Rice: Sweetened condensed milk. V. Rancidity. Jour. Dairy Sci., ix, 1926, 293.
Greenbank and Holm: Jour. Ind. Eng. Chem., xvi, 1924, 598.
(4) Palmer and Combs: Jour. Dairy Sci., ii, 1919, 444.

FACTORS FOR ADJUSTING MILK AND BUTTERFAT RECORDS OF REGISTER OF MERIT JERSEY COWS TO A UNIFORM AGE BASIS*

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The influence of age on the production of milk and butterfat by dairy cows is not a new problem, and dairy literature contains much information on the subject. In 1917 (1) Pearl and Patterson reported the results of an analysis of seven-day Jersey milk records taken from "Jersey Sires and Their Tested Daughters," a publication issued by the American Jersey Cattle Club in 1909. One of the conclusions of these authors was that maximum production is reached at approximately the age of 8 years and 7 months. In 1919, Pearl, Gowen, and Miner (2) studied 2153 yearly milk records from the first two volumes of the Register of Merit and concluded that the actual maximum mean milk yield comes at 8.12 years. The following is quoted from their paper: "In these Jersey cows the absolute amount of milk produced per unit of time increases with the age of the cow until a maximum is reached, but the amount of increase diminishes each year with advancing age until the absolute maximum production is reached."

Later, Gowen (3) studied 1741 complete eight-months lactation periods of Jersey cows from records in a single herd. He writes as follows: "The mean milk production for the eight-months period for those cows which are between 2 and 3 years of age, is 4032.9 pounds. From this point the milk production rises rapidly at first then more slowly to a maximum at about 7 years. From this maximum the decline in milk production is less rapid toward the higher ages." Here is a variation of about one year in the age of maximum production of cows of the same breed.

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In 1921, Hooper (4) reported the results of a study of 1497 Jersey records from the 1916 Volume of the Register of Merit, and in the following year McCandlish (5) added further knowledge on the subject of the effect of age on production. The latter used a total of 5772 Jersey records from the Register of Merit to July, 1916. These were grouped by ages according to the year in which the test began. The author concludes that the maximum milk and butterfat yield is reached at about eight years of age, and that the fat percentage of Jerseys rises from one to four years and then decreases irregularly.

Most of the foregoing work was criticised by Ragsdale, Turner, and Brody (6) because of the limited data employed. They consolidated 195,678 records from the Jersey Register of Merit, Shorthorn Record of Merit, and Ayrshire, Guernsey, and Holstein Advanced Registers into a composite curve showing the effect of age on production. In the individual breed studies they used 13,723 Jersey records, and the 565 animals from eight to nine years of age show the highest average butterfat production.

The purpose of the present study was to determine the effect of age alone on milk and butterfat production of Register of Merit Jersey cows. Although the material used has been criticised because of the selective influence which Register of Merit requirements exert on official records, yet the fact remains that one of the principal uses to which the results are to be applied is the adjustment of Register of Merit records to a standard age; and it would appear that correction factors derived from the same source as that to which they are to be applied are more nearly accurate than those from any other source. Needless to say, age relationship as determined from more than 14,000 Register of Merit records would likely be sufficiently characteristic of the Jersey breed to make the application of these correction factors to any Jersey records reasonably accurate.

As has been shown elsewhere (7), the increase in production from an initial to a reentry record is due partly to increased age and partly to the development which the animal undergoes during the initial test. This development averages 11 per cent

of the reentry record for Register of Merit Jerseys. Because of this fact all reentry records have been omitted from this study of the influence of age on production, and the results are based on an analysis of 14,571 initial Class-A and Class-AA Jersey records contained in the Register of Merit up to and including the 1921 Volume. By discarding the reentry records the distorting influence of the factor of development is eliminated, as it will be shown that certain age groups have decidedly higher proportions of reentry records than others, thereby weighting the influence of development in these groups. Furthermore, the inclusion of reentry records tends to introduce the additional influence of selection exercised by the breeders in retesting more of their better cows (7). This would again raise the average of the age groups having the greater proportion of reentry records.

In the case of Gowen's (3) study of 1741 private records, it goes without saying that those in charge of the herd where the records were made used the heifer records as a basis for culling the nonproducers. If they failed to do so, then what was the purpose of the testing? If no low producers were eliminated, it must be assumed that there was an unusual increase in the number of females; or that cows were sold in their early maturity regardless of producing ability; or that the death rate equaled the birth rate, which would indicate a condition of herd health such as to make the records of doubtful value for statistical analysis.

Our data confirm a well established popular belief that the maximum producing ability of dairy cows extends over a period of several years after they attain maturity. In most previous studies it has been shown that the age of maximum production is reached at some fixed time, such as 8 years, 1 month, 13 days. That any certain breed or any individual cow would reach her maximum producing capacity on such a narrowly prescribed time limit does not seem logical. Athletes, as rule, during a period of their lives are capable of performing at a fairly uniform rate; and the same is true of race horses. Utmost physical ability in most lines of endeavor as well as mental capacity continue unabated over a period of time.

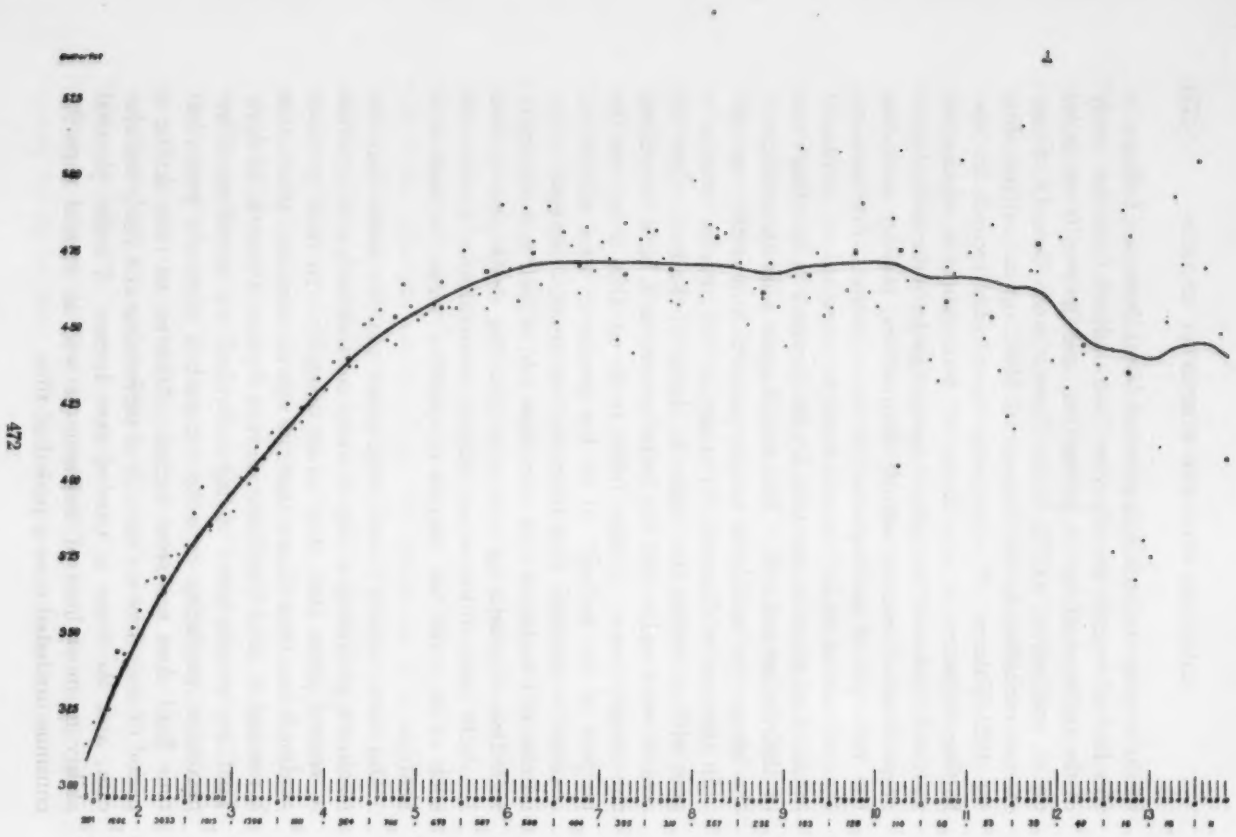

FIG. 1. INFLUENCE OF AGE ON BUTTERFAT PRODUCTION

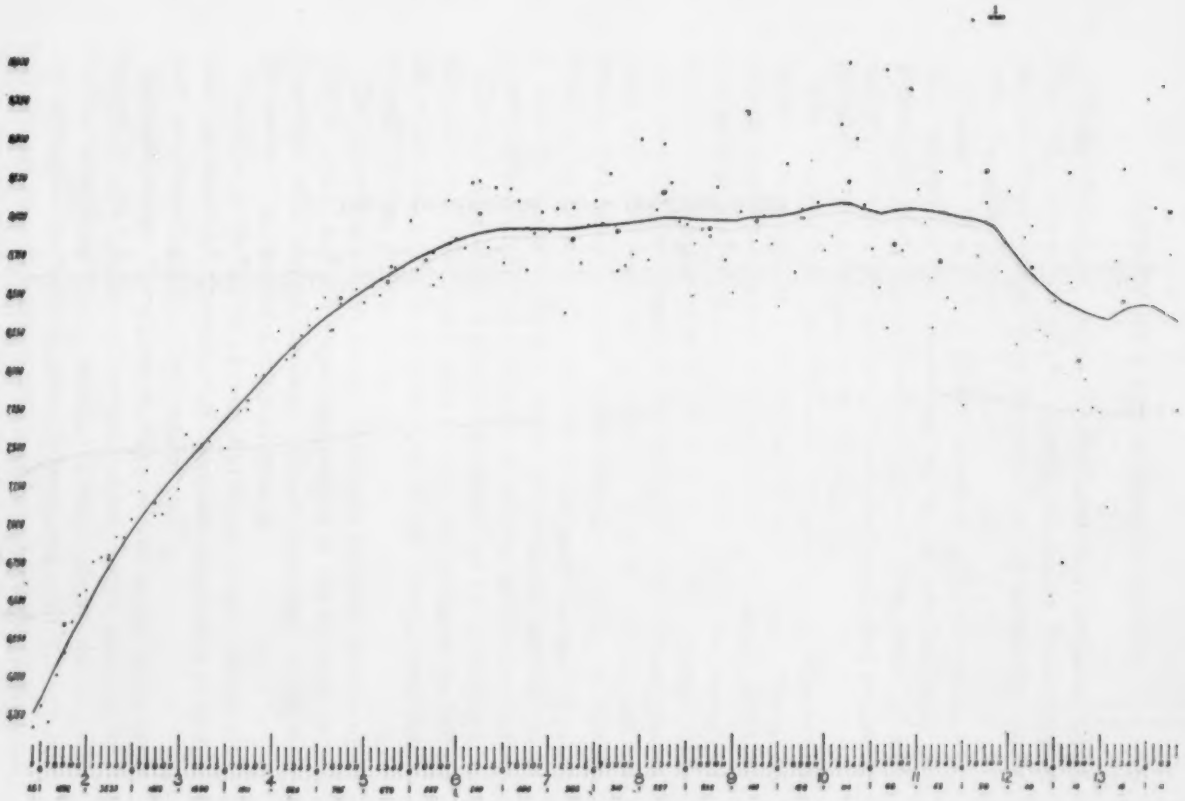

FIG. 2. INFLUENCE OF AGE ON MILK PRODUCTION

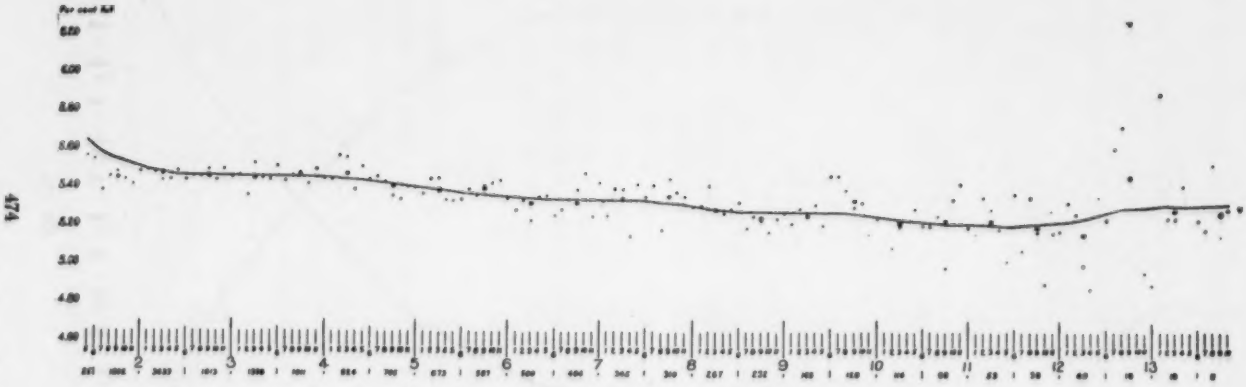

FIG. 3. INFLUENCE OF AGE ON PER CENT OF FAT

If due allowance is made for environmental influences, which limit the value of all official records, the minor fluctuations in records of cows tested more than once during mature life can be fully accounted for.

Figures 1, 2, and 3 show the curves of butterfat production, milk production, and percentage of fat, as evolved from the Register of Merit data already described. The curves of milk and butterfat production show that there is a period of maximum production from the age of 6 to 10½ years.

The trend of both the milk and butterfat production curves shows a sharp change at about the age of 6 years. The curve of milk production continues to rise slowly until about 10½ years of age, when the trend changes. However, the total increase in milk during this period of 4½ years is about 200 pounds, which may be attributed largely to the influence of three small groups (ages 10-2, 10-3, and 10-4) numbering only 45 animals, and including five records above 13,000 pounds of milk. A further contributing factor to this increase at the ages of 9 and 10 years is that the animals officially tested at advanced ages are more closely selected, and only animals of unusual ability are tested.

The influence of the declining percentage of fat is sufficient to offset the slight rise in milk after 6 years and to change the butter fat production curve to a horizontal, which remains practically so until the age of 10½ years.

The percentage of fat shows an almost uniform decline until after 11 years, and the succeeding portion of the curve is based on groups with limited numbers. This corresponds to Gowen's (8) observations on percentage of Jerseys.

The type of the curves of milk and butterfat production confirms the belief that the period of maximum production of Jersey cows continues from 6 to 10½ years of age.

Unquestionably the shape of these curves would have been changed by the inclusion of reentry records, which were omitted for the reasons previously stated. Table 1 shows the number and average initial records used as compared with the number and average records which would have been added to each group if the reentry records had been included. The younger classes

receive little or no influence from the relatively higher reentry records. The table shows that every class from 4½ up to 8½ years would have had over 50 per cent additional records averaging from 14.3 per cent to 20.5 per cent higher than the initial records.

To facilitate the work of adjusting Register of Merit records to a standard age basis, table 2, containing factors for correcting

TABLE 1

Initial and reentry records of Register of Merit Cows

AGE	INITIAL RECORDS USED		REENTRY RECORDS OMITTED		RATIO OF REENTRY TO INITIAL RECORDS	DIFFERENCE BETWEEN INITIAL AND REENTRY
years	*number*	*pounds*	*number*	*pounds*	*per cent*	*pounds*
Under 2	1237	343	0			
2 to 2½	3633	368	0			
2½ to 3	1313	386	51	412	3.9	26
3 to 3½	1298	404	367	468	28.3	64
3½ to 4	1011	423	374	490	37.0	67
4 to 4½	924	440	422	505	45.7	65
4½ to 5	705	454	370	532	52.5	78
5 to 5½	673	457	372	525	55.3	68
5½ to 6	587	469	326	543	55.5	74
6 to 6½	509	475	268	543	52.7	68
6½ to 7	404	471	237	543	58.7	72
7 to 7½	395	468	215	564	54.4	96
7½ to 8	310	470	185	553	59.7	83
8 to 8½	267	480	140	565	52.4	85
8½ to 9	232	462	93	573	40.1	111
9 to 9½	163	468	77	559	47.2	91
9½ to 10	128	475	63	549	49.2	74
10 to 10½	114	476	40	530	35.1	54
10½ to 11	68	459	29	574	42.6	115

milk and butterfat records, has been prepared from our data. The relatively slight variation in percentage of fat due to age does not warrant the application of correction factors, unless they be used in a gross way; furthermore, there are factors for adjusting both milk and butterfat records. The correction tables are prepared for ages in years and months for reasons which will be demonstrated. Criticism that this involves too much detail can readily be answered by the results shown in

applying various correction factors. Unless records are standardized with care and precision, results will be badly distorted. For example, suppose two heifers complete records of 500 pounds of butterfat. Heifer A began her test at 2 years and 10 days, while heifer B started at 2 years, 5 months, and 10 days of age.

TABLE 2

Factors for correcting Register of Merit Jersey records to mature age basis

Procedure: Multiply the actual record by the factor shown opposite the age at which the record was made in order to obtain the age-corrected record.

AGE		MILK FACTOR	BUTTERFAT FACTOR	AGE		MILK FACTOR	BUTTERFAT FACTOR	AGE		MILK FACTOR	BUTTERFAT FACTOR
years	*months*			*years*	*months*			*years*	*months*		
1	5	1.55	1.51	3	1	1.21	1.18	4	9	1.07	1.05
1	6	1.53	1.50	3	2	1.20	1.17	4	10	1.06	1.04
1	7	1.50	1.47	3	3	1.19	1.16	4	11	1.06	1.04
1	8	1.48	1.44	3	4	1.18	1.15	5	0	1.05	1.03
1	9	1.45	1.41	3	5	1.18	1.15	5	1	1.05	1.03
1	10	1.43	1.39	3	6	1.17	1.14	5	2	1.05	1.03
1	11	1.41	1.37	3	7	1.16	1.13	5	3	1.04	1.03
2	0	1.39	1.35	3	8	1.15	1.12	5	4	1.04	1.02
2	1	1.37	1.33	3	9	1.14	1.11	5	5	1.03	1.02
2	2	1.35	1.31	3	10	1.14	1.11	5	6	1.03	1.02
2	3	1.33	1.30	3	11	1.13	1.10	5	7	1.03	1.02
2	4	1.32	1.28	4	0	1.12	1.09	5	8	1.02	1.01
2	5	1.30	1.27	4	1	1.11	1.09	5	9	1.02	1.01
2	6	1.29	1.25	4	2	1.11	1.08	5	10	1.02	1.01
2	7	1.28	1.24	4	3	1.10	1.07	5	11	1.02	1.01
								years			
2	8	1.26	1.23	4	4	1.09	1.07	6	to 10½	1.00	1.00
2	9	1.25	1.22	4	5	1.09	1.06	10½	to 12	1.01	1.02
2	10	1.24	1.21	4	6	1.08	1.06	12	to 14	1.05	1.06
2	11	1.23	1.20	4	7	1.08	1.05	14 and over		1.14	1.12
3	0	1.22	1.19	4	8	1.07	1.05				

In a rough classification both would be called junior two-year-olds. Applying correction factors in Table 2 gives the following results: Heifer A, 500 × 1.35 = 675 pounds, mature equivalent; heifer B, 500 × 1.27 = 635 pounds, mature equivalent. The difference is 40 pounds of butterfat.

If the conversion factor of Turner, Ragsdale, and Brody (9)

were applied, both heifers A and B would have mature equivalent records of 725 pounds of fat, or 50 pounds more than A and 90 pounds more than B, as determined above.

It might be of interest to apply the correction factors to a number of Register of Merit records. As a comparative group of Register of Merit cows, the various class leaders have as a common distinction the fact that each is supreme in her own age division. In table 3 are the actual and age-corrected records of the 365-day class leaders as listed in the Jersey Bulletin of July 29, 1925.

TABLE 3

CLASS	NAME	BUTTER-FAT RECORD	AGE		AGE-CORRECTED RECORD
		pounds	years	months	pounds
Yearling....	St. Mawes Lad's Lady	829	1	11	1,136
Jr. 2.....	Raleigh's Torono Meme	902	2	5	1,146
Sr. 2.....	Sensation's Mikado's Millie	850	2	8	1,046
Jr. 3.....	Poppy's Dortha	994	3	4	1,143
Sr. 3.....	St. Mawes Lad's Pride	1,002	3	7	1,132
Jr. 4.....	Darling's Jolly Lassie	1,141*	4	0	1,244
Sr. 4.....	Vive La France	1,031	4	7	1,083
Mature.....	Groff's Constance	1,130	5	3	1,164

* Highest record for the Jersey breed.

The most butterfat which any Jersey cow has ever produced during a year while an official test is 1141 pounds. This figure indicates the utmost ability of the best cow among some 22,000 cows which have been admitted to the Register of Merit. Of all the animals over five years of age, which are classed as mature, the best producer has a record of 1130 pounds of butterfat. The various class leaders are the best producers in their respective age divisions, and when the age-correction factor is applied to each record it is interesting to observe how closely the adjusted records approximate the highest of the breed. The record of Darling's Jolly Lassie, when corrected for age, exceeds anything which has yet been achieved by a Jersey cow; but it is not inconceivable that this is an exceptionally precocious and

early maturing animal; and unless she demonstrates at a later date an increased ability, her record as a four-year-old marks her full capacity to produce butterfat. Records of all other classes, when adjusted for age, group fairly well around the actual high record for the breed. The average age-corrected record for the eight class leaders is 1137 pounds—only 4 pounds below the actual record of Darling's Jolly Lassie, and 7 pounds in excess of the actual record of Groff's Constance, the highest producer among the cows over five years of age.

By way of comparison with the above, the same records and the adjusted records secured by use of the tables of Turner,

TABLE 4

CLASS	ACTUAL RECORD	AGE		ADJUSTED RECORD—TURNER, RAGSDALE, AND BRODY	ADJUSTED RECORD—DAVIDSON
	pounds	*years*	*months*	*pounds*	*pounds*
Yearling	829	1	11	1,227	1,227
Jr. 2	902	2	5	1,308	1,218
Sr. 2	850	2	8	1,139	1,105
Jr. 3	994	3	4	1,243	1,203
Sr. 3	1,002	3	7	1,162	1,182
Jr. 4	1,141	4	0	1,278	1,301
Sr. 4	1,031	4	7	1,113	1,134
Mature	1,130	5	3	1,187	1,198
Average				1,207	1,196

Ragsdale, and Brody (9), and one developed by Davidson (10) from data previously cited (2) are listed in table 4.

Six of the adjusted records in each list is in excess of the highest record ever made, 1141 pounds. One corrected record in each list exceeds 1300 pounds of butterfat, and three others in each are above 1200 pounds. Of the thousands of mature cows which have undergone Register of Merit tests, Groff's Constance tops the list with 1130 pounds. If such marked ability existed as is shown by the age-corrected records of young cows in these two lists, similar ability and higher records for the mature class should be found. Unless the records adjusted from earlier ages agree

fairly well with what the cows actually produce when mature, then the correction factors are at fault.

SUMMARY

A table of factors for adjusting Register of Merit Jersey milk and butterfat records to a standard age basis has been evolved from the initial records found in the Register of Merit up to and including the 1921 Volume.

The result of the application of these factors to actual records is compared with results secured by the use of other correction factors.

The production curves of Register of Merit cows indicate that the period of maximum producing ability continues from 6 to 10½ years of age.

REFERENCES

(1) Pearl, Raymond, and Patterson, S. W.: Maine Sta. Bul. 262, July, 1917.
(2) Pearl, R., Gowen, J. W., and Miner, J. R.: Maine Sta. Bul. 281, October, 1919.
(3) Gowen, John W.: Maine Sta. Bul. 286, 1920.
(4) Hooper, J. J.: Kentucky Sta. Bul. 234, 1921.
(5) McCandlish, A. C.: Iowa Sta. Research Bul. 73, 1922.
(6) Ragsdale, A. C., Turner, C. W., and Brody, S.: Jour. Dairy Sci., vii, no. 2, March, 1924.
(7) Graves, R. R., and Fohrman, M. H.: U. S. Dept. of Agr., Bul. 1352, August, 1925, pp. 5, 20, table 24.
(8) Gowen, John W.: Maine Exp. Sta. Bul. 290, August, 1920.
(9) Turner, C. W., Ragsdale, A. C., Brody, S.: Missouri Ag. Exp. Sta. Bul., no. 221, September, 1924.
(10) Davidson, F. A.: Illinois Exp. Sta. Bul. 270, June, 1925.

THE EFFECT OF HEATING ON THE HYDROGEN-ION CONCENTRATION AND ON THE TITRATABLE ACIDITY OF MILK*

E. O. WHITTIER AND ANNE G. BENTON

Research Laboratories, Bureau of Dairying, United States Department of Agriculture, Washington, D. C.

INTRODUCTION

Surprisingly little work has been reported on the changes in hydrogen-ion concentration and in titratable acidity which occur when milk is heated. Since the first factor is a major determinant in the coagulation of milk, and since both should give evidence as to the character and extent of chemical changes involving acids, a determination of these values over a considerable range of temperature and time of heating is desirable.

PREVIOUS WORK

Kirsten (1) found a decrease in the titratable acidity of milk after heating for a short time at various temperatures. Centrifuging milk caused a somewhat smaller decrease in titratable acidity. Heating of the centrifuged milk caused a still further drop. He showed that these changes could be correlated with and accounted for by the loss of carbon dioxide.

Orla-Jensen and Plattner (2) found that by heating milk for five minutes at temperatures as high as 110°, a decrease in titratable acidity was obtained; at higher temperatures an increase was found. Heating for an hour at 110° gave an increase. A development of color in the milk accompanied the increase in titratable acidity. They explained the decreases in titratable acidity by loss of carbon dioxide; the increase by development of acid, largely from the casein and to a less degree from lactose.

Van Dam (3) found an increase in hydrogen-ion concentration and a decrease in titratable acidity after heating milk for periods

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of not more than an hour. He attempted no explanation of this seeming paradox, but took the hydrogen-ion change to indicate that the calcium caseinate is not hydrolyzed in the heating of milk, and hence the greater stability of heated milks cannot be explained on the basis of such an hydrolysis.

Duncombe (4) reported values for titratable acidity and hydrogen-ion concentration on milks measured *at* different temperatures. He found both values increased by raising the temperature. These measurements are very significant, but, until the temperature range of reliable measurement of hydrogen-ion concentration can be extended much higher than is now possible, the value of such figures is rather limited and attempts at their interpretation unsafe.

Cosmovici (5) heated milk for periods of thirty minutes at temperatures of 56°, 68°, 75° and 100° and states that the hydrogen-ion concentration was increased to an extent dependent on the temperature and time of heating, and that the change was irreversible.

Apparently no one has measured the changes in these values over any extended period of heating. We are making such measurements and report here on two typical experiments, one at the boiling point of milk, the other at 95°.

EXPERIMENTAL

For each of the experiment reported here, 3 liters of fresh, separated herd milk were used. The initial pH in one experiment was 6.55, in the other 6.61. The round-bottom flask, in which the heating was carried out, was provided with a reflux condenser and a thermometer and was immersed to above the level of the surface of the milk in a bath of saturated salt solution in which was suspended a second thermometer. In the 95° experiment, the temperature of the salt bath was raised to about 100° and held there till the milk had reached 90°, after which it was held at 95 to 96°. In the experiment at boiling temperature, the bath was raised to 106 to 107° and maintained there. Samples were removed hourly by means of a syphon, which could be blown clear after each sampling. The samples were cooled immediately

to room temperature by means of ice-water and the necessary determinations made at once.

The hydrogen-ion determinations were made in duplicate in Clark rocking electrode vessels, a saturated calomel half-cell completing the chain. A Type K Leeds and Northrup potentiometer was used for the measurements. A lead accumulator was used as a source of potential for the comparisons, and this potential was kept at a constant known value by frequent balancing against a Weston cell which had been calibrated by the Bureau of Standards. The value of the calomel half-cell was checked each day before using by means of an M/20 solution of potassium hydrogen phthalate. The milk samples were cooled to the temperature of the measuring system before determining their hydrogen-ion concentration. Results were not recorded until the duplicates in the two cells checked to 0.01 pH unit.

A preliminary experiment showed that it was not practicable to titrate the heated milk with phenolphthalein as indicator, because of the peculiar brownish color which masked the end-point to increasing degrees as the heating progressed. Therefore, we decided to titrate electrometrically to an end-point at pH 8.0, which is the end-point most people obtain approximately by using phenolphthalein in milk.

A Hildebrand electrode immersed in the milk in a jelly glass was used for the titrations. The saturated potassium chloride bridge was a piece of glass tubing drawn to an upward-pointing fine tip at the end immersed in the milk. The bridge had in it a stopcock that was kept closed during titrations. The other half of the chain was a saturated calomel half-cell. The same potentiometer, accumulator, and standard cell were used as in the hydrogen-ion determinations.

To a 50 cc. sample of the milk cooled to the temperature of the measuring system was added N/10 sodium hydroxide till near the end-point. The electrode and bridge were then immersed and the potentiometer adjusted to the null point. Two minutes were sufficient for the attainment of equilibrium when the electrode was previously saturated with hydrogen. Standard alkali was then added slowly till equilibrium was obtained at the poten-

tiometer reading corresponding to pH 8.0. No difficulty was found in duplicating results. The end-points were checked in a few cases by making hydrogen-ion determinations on the titrated samples with the Clark electrodes.

DISCUSSION

Figures 1 and 2 show the results obtained. In plotting the curves, the time when the milk reached the temperature at which it was subsequently maintained was taken as zero time. The values at the left of the zero line are the values obtained on the unheated milk. Titratable acidity has been plotted as cubic centimeters of N/10 sodium hydroxide solution necessary to bring 100 cc. of milk to pH 8.0. Hydrogen-ion concentration has been plotted as actual normality of hydrogen ions times 10^4, to avoid the common difficulty of grasping the magnitudes of the differences between the logarithmic values of pH.

The milk at the higher temperature (fig. 1) was visibly coagulating after thirteen hours heating. The shape of the hydrogen-ion concentration curve seems to indicate that the beginning of coagulation was about two hours earlier. The milk held at 95° had not coagulated when the heating was discontinued. This lower temperature curve is included mainly to show the differences in the rates of change of hydrogen-ion concentration and titratable acidity at different temperatures.

The explanation of previous workers that evolution of carbon dioxide is the cause of the initial drop in titratable acidity of heated milk is without doubt the true one. That this effect is superimposed upon and completely masks for a brief time the production of acid from some constituent of the milk is a point that has been reported only by Orla-Jensen and Plattner (2). Their statement that this acid comes mostly from casein decomposition and to only a slight extent from lactose is supported by titratable acidity values on unheated and heated lactose solutions and on heated casein solutions with and without lactose present. They do not give titratable acidities on their casein solutions before heating; they do not state the technique employed in their casein titrations; nor is it clear to what extent their

casein was identical with the casein of fresh milk. We propose to attack this problem from a different angle and hope to corrobo-

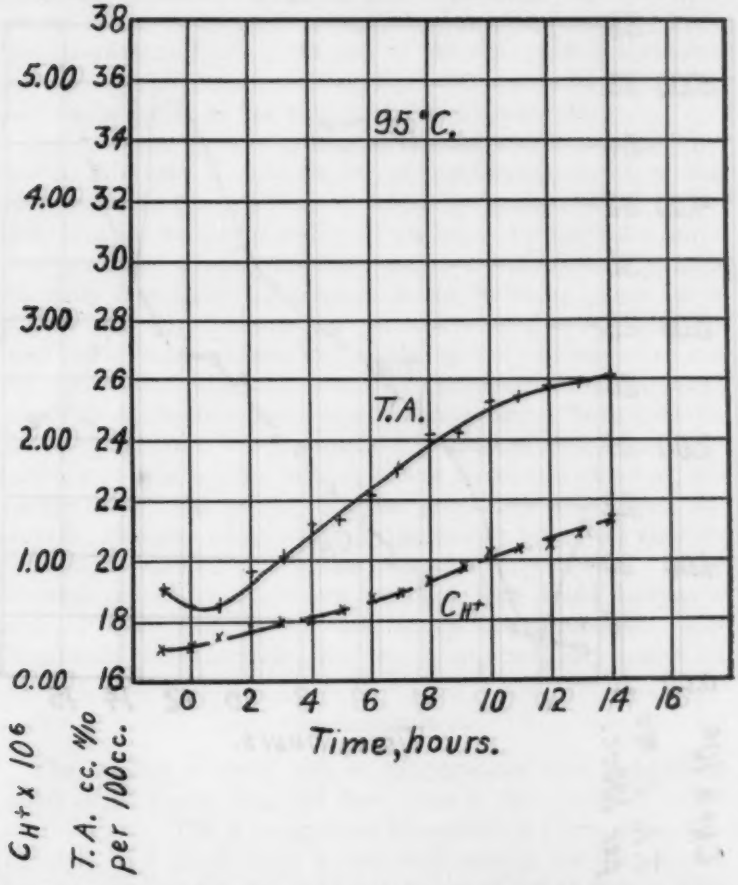

FIG. 1. EFFECT OF HEATING AT 101.5°C. ON THE HYDROGEN-ION CONCENTRATION AND ON THE TITRABLE ACIDITY OF MILK AT 95°

rate or to disprove their conclusion on a somewhat more substantial basis. An explanation of the reversing curvature of the titratable acidity curve during the first twelve hours heating may

be easier when the source and identity of the acids formed is more firmly established. It should be noted that the rate of production

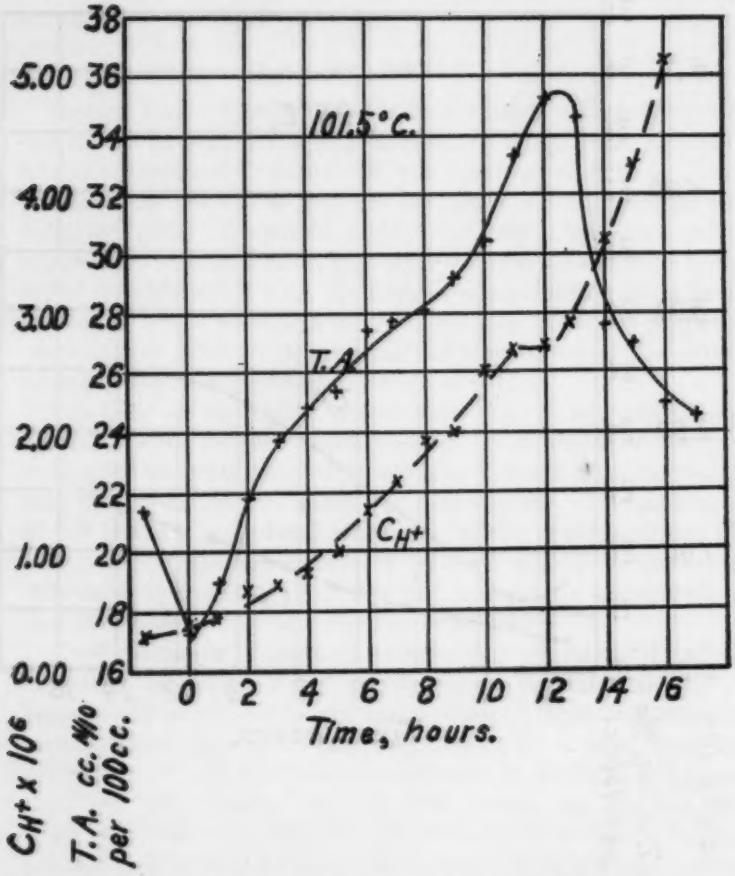

FIG. 2. EFFECT OF HEATING AT 95°C. ON THE HYDROGEN-ION CONCENTRATION AND ON THE TITRATABLE ACIDITY OF BOILED MILK

of acid at 95° is much less than at the boiling temperature, but the curvature for the first fourteen hours at 95° is comparable with that for the first seven hours at 101.5°.

The decrease of the titratable acidity after twelve hours boiling represents the change in acidity in the fluid portion from which increasing amounts of coagulum have separated. Titration of a sample of the curdy portion, which had separated roughly from the supernatant fluid at the end of the run, gave a titratable acidity value of 50.9 cc. N/10 acid per 100 cc., showing that the acid concentrates in the curd, probably by adsorption.

The increase in the hydrogen-ion concentration caused by heating skim milk is fairly regular, as might be expected from the assumption that it is the result of the interaction of the buffer system of the milk with acids that are being produced at a fairly constant rate. During the early stages of coagulation there is evidently a considerable increase in the buffering power for a short time. The hydrogen-ion concentration then reëstablishes itself on a sharper slope, and at the end of sixteen hours has reached a point which it would have reached had it continued smoothly at the curvature it was following during the first eleven hours of heating. The decrease of hydrogen-ion concentration which takes place when heated milk is allowed to stand at low temperatures, and which has been previously noted, was observed. Samples which stood in the ice-box for about twenty-four hours showed a decrease numerically equivalent to the increase caused by two hours heating. This would indicate a shift of buffer equilibrium with change of temperature. The magnitude of this reversion is so small that it is of only theoretical interest.

CONCLUSIONS

The heating of skim milk at temperatures near the boiling point causes first a drop and then a rise in the titratable acidity of the milk. The hydrogen-ion concentration increases continuously. The initial drop in titratable acidity has been shown by previous investigators to be due to loss of carbon dioxide from the milk; the increases in titratable acidity and in hydrogen-ion concentration are due to the formation of acids from certain constituents of the milk. During coagulation, the rate of change of hydrogen-ion concentration is considerably lessened due to

buffer readjustments not yet explained in detail. At the same time, there is an uneven distribution of the free acid between the whey and the curd, due probably to adsorption of the acid by the curd.

The amount of acid production is dependent on both time and temperature of heating. We do not agree entirely with previous workers as to the sources of the acid, and shall present in a future paper experimental data bearing on the nature of the chemical reactions involved.

REFERENCES

(1) KIRSTEN: Z. Nahr. Genussm., v, 97 (1902).
(2) ORLA-JENSEN AND PLATTNER: Landw. Jahrb. Schweiz., xix, 235 (1905).
(3) VAN DAM: Milchwirtschaft. Zentr., v, 154 (1909).
(4) DUNCOMBE, J.: Dairy Sci., vii, 245 (1924).
(5) COSMOVICI: Compt. rend. soc., biol., xcii, 73 (1925).

AN APPRECIATION

A distinct tribute was paid Dr. C. H. Eckles, Head of the Dairy Department, University of Minnesota, during Farmers' Week when the Eckles Club, composed of his former students, presented an oil painting of their "Chief." This portrait was unveiled and hung in the new dairy building of the University on January 22.

The presentation was made by C. M. Long of the Blue Valley Creamery Institute, who fully expressed the sentiments of the club when he said: "The members of the Eckles Club feel that they owe a debt of gratitude to their Chief bigger than they will ever be able to pay. Desiring to express in some small way this debt, they have had this portrait painted."

Dr. Eckles' former students may be found wherever dairy cows are milked and dairy products are manufactured. They are engaged in all branches and in all phases of the dairy industry. In his teaching and investigational work, first at the University of Missouri and later at the University of Minnesota, he has had greater influence on the practice and profession of dairying than any other living man today.

The sole purpose of the Eckles Club is to meet once a year at the National Dairy Show for a friendly get-together and to receive counsel and advice from the "Chief." There are now about 115 members and the membership is increasing at the rate of about five each year.

Dean W. C. Coffey of the College of Agriculture, University of Minnesota, in accepting this portrait for the University made the following statement:

I doubt if any other man in agricultural education now or in the past has trained as many men who have risen to responsible positions as has Professor Eckles. His standing in the educational field as it related to dairying is unequaled and his influence in that field now is

profound. He is quiet, unassuming, always modest, always cheerful, always fair. His power lies in keeping his well trained mind at work on objectives he clearly understands, and in giving all he has to his position and to the young men who work and study under him. With him the course of friendship runs deep; it is never ephemeral with him, and he never uses superficial methods to get it.

In these young men who constitute the Eckles Club, he has accumulated great riches which will continue to grow as he unselfishly shares them with the world. How paltry is mere money beside them! It is with this feeling,—a feeling, by the way, to which every member of the faculty on this campus would instantly subscribe—that I accept this portrait for the Department of Agriculture, University of Minnesota.

ANNUAL MEETING OF THE AMERICAN DAIRY SCIENCE ASSOCIATION

The twenty-first annual convention of the American Dairy Science Association will be held at Detroit, October 8 and 9.

The Book-Cadillac Hotel will be association headquarters and there all meetings will be held. Single rooms are $4; doubles, $6. Other good hotels are the Wolverine, Tuller and Fort Shelby.

Here are the high points in the meetings:

October 8: Morning; general meeting, addressed by Pres. Butterfield of the Michigan State College.

October 8: Afternoon; sectional meetings.

October 8: Evening; banquet, address by Secretary of Agriculture Jardine, and Judging Contest awards announced.

October 9: Morning; general session.

THIS IS GOING TO BE A BIG SHOW. Besides the usual attractions of the National Dairy Exposition, the greatest trade exhibit in the history of the country will be staged. Several convention records will be broken. Let's all go and make it a record breaker for the A. D. S. A.

Faithfully,

G. C. WHITE,
Secretary-Treasurer.

PROGRAM

GENERAL SESSION

BOOK-CADILLAC HOTEL, DETROIT, MICH.

Friday, October 8, 1926, 9:00 a.m.

Call to Order by President.....O. E. Reed, East Lansing, Mich.
Reading of Minutes by Secretary.....G. C. White, Storrs, Conn.
Secretary and Treasurer's Report.....G. C. White, Storrs, Conn.

Appointment of Nominating Committees.
Divisional Reports: Eastern Division, Southern Division, Western Division.
Reports of Standing Committees.
Address.....Dr. Kenyon L. Butterfield, East Lansing, Mich.
Discussion: The Development of the Work of the American Dairy Science Association.

General Session

BOOK-CADILLAC HOTEL

Saturday, October 9, 1926, 9:00 a.m.

Call to Order by President.....O. E. Reed, East Lansing, Mich.
Report of Sections:
Section I.....C. C. Hayden, Wooster, Ohio
Section II.....A. C. Baer, Stillwater, Okla.
Section III.....A. J. Cramer, Madison, Wisc.
Section IV.....C. E. Wylie, Knoxville, Tenn.
Committee Reports.

Banquet

NEWCOMB ENDICOTT TEA ROOM

Friday, October 8, 1926, 6:30 p.m.

Toastmaster.....H. F. Judkins, Springfield, Mass.
Address.....Hon. W. M. Jardine, Secretary of Agriculture, Washington, D. C.
Announcement of Awards and Presentation of Prizes in the InterCollegiate Judging Contests.

(Banquet tickets $1.50 per plate)

PROGRAM

Section I. Production

Friday, October 8, 1926, 2:00 p.m.

C. C. Hayden, Ohio, *Chairman*
O. G. Schaefer, Minnesota, *Secretary*

What we know about controlling abortion disease.....Dean G. C. White, Storrs, Conn.
What experiments to date show about minerals for dairy cows
Dr. E. B. Forbes, Director, Institute of Animal Nutrition, State College, Pa.
Report of committee on future coöperative work in mineral investigations
Dr. E. B. Meigs, Bureau of Dairy Industry, Washington, D. C.

Business.
Reports of Judging Committee, at banquet.

Section II. Manufacturing

Friday, October 8, 1926, 2:00 p.m.

A. C. Baer, Oklahoma, *Chairman*
C. D. Dahle, Pennsylvania, *Secretary*

Call to Order by Chairman
Reading of Minutes by Secretary

Reports of Standing Committees:
- National Contest for Judging Dairy Products.....R. B. Stoltz
- Score Cards and Legal Standards.....J. H. Frandsen
- Chemical Methods of Testing Dairy Products.....A. C. Dahlberg
- Methods of Determining Milk Solids-not-fat.....H. C. Troy
- Testing Ice Cream for Total Solids.....R. C. Fisher
- Official Methods of Testing Milk and Cream.....F. W. Bouska
- Bacteriological Methods.....R. S. Breed
- (a) Sub-Committee on Ice Cream.....A. C. Fay
- College Creameries.....C. L. Roadhouse
- Economic Phases of the Dairy Industry.....Roy C. Potts

The effect of processing on the dispersion of fat in an ice cream mix
Wm. H. E. Reid, Columbia, Mo.

Discussion: Relation of sugar to overrun and quality
P. L. Lucas, East Lansing, Mich.

Discussion: Some new developments in ice cream making
H. H. Sommer, Madison, Wis.

Body of Butter.....E. S. Guthrie, Ithaca, N. Y.

Discussion—(a) Body as it affects moisture holding quality....F. W. Bouska
(b) Effect of working on the body, etc.....O. F. Hunziker

Uniformity of methods of manufacture of cottage cheese
Carl E. Lee, Gridley Dairy Company, Milwaukee, Wisc.

Discussion: Preservation of cottage and cream cheeses in vacuo
J. M. Sherman, Ithaca, N. Y.

Discussion: Cream Cheeses.....A. C. Dahlberg, Geneva, N. Y.

Section III. Advanced Registry

Friday, October 8, 1926, 2:00 p.m.

C. Elmer Wylie, Tennessee, *Chairman*
W. E. Petersen, Minnesota, *Secretary*

Minutes of last meeting.
Report of Breed's Relation Committee..M. H. Campbell, Chairman, Illinois.
Report of Investigation Committee.....Roy Harris, Chairman, Wisconsin.
History and Trend of Official Testing.....Dr. C. H. Eckles, Minnesota.
The Ayrshire Herd Test Plan
C. T. Conklin, Secretary, Ayrshire, Breeders Association
Supervising the Herd Test Plan..... Prof. P. S. Williams, Pennsylvania
Remarks by Breed Association Representatives:
- American Jersey Cattle Club
- American Guernsey Cattle Club
- Ayrshire Breeders Association
- Brown Swiss Cattle Breeders Association
- Dutch Belted Cattle Association of America
- Holstein-Friesian Association of America
- Shorthorn Breeders Association

Reports of Special Committees.
Election of Officers.

Section IV. Extension

(Program has not been received.—*Editor*)

AMERICAN DAIRY SCIENCE ASSOCIATION MEMBERSHIP FOR 1926

The following is a list of the membership of the American Dairy Science Association for 1926. Any member whose name does not appear in this list should communicate at the earliest convenience with Secretary G. C. White, Storrs,Conn.—*Editor.*

ADAMS, C. F.....5014 E. Seventh Street, Kansas City, Mo.
ADAMS, DAVID P.....Department of Agriculture, Nashville, Tenn.
ADDINGTON, L. H.....Michigan Agricultural College, East Lansing, Mich.
ADDY, R. H.....Allegan, Mich.
ALLEN, C. L.....Cornell University, Ithaca, N. Y.
ALTWEGG, C. A.....Gluckskille Milchgesellschaft, Neustadt in Holstein, Germany
ANDERSON, E. O.....Dairy Department, Storrs, Conn.
ANTHONY, E. L.....Morgantown, W. Va.
AREY, J. A.....Dairy Extension, State College, Raleigh, N. C.
ASHTROTH, FRANK B.....1437 Chelmsford Avenue, St. Paul, Minn.
ATKESON, F. W.....Dairy Department, Moscow, Idaho

BAER, A. C.....Dairy Department, Stillwater, Okla.
BALTZER, A. C.....Dairy Department, East Lansing, Mich.
BAUMAN, A. W.....212–18 Curtis Street, Chicago, Ill.
BEAM, A. LELAND.....State College, Pa.
BECHDEL, S. I.....State College, Pa.
BECKER, R. B.....Dairy Department, Oklahoma A. & M. College, Stillwater, Okla.
BECKMAN, H. C.....600 Jackson Boulevard, Chicago, Ill.
BELE, FRANK.....University of Minnesota, St. Paul, Minn.
BELL, R. W.....1357 Park Road, Washington, D. C.
BENDIXEN, H. A.....Moscow, Idaho
BENNETCH, P. B.....State Department of Agriculture, Trenton, N. J.
BENNETT, FREDERICK W.....Georgia State College of Agriculture, Athens, Ga.
BESEMER, A. M.....Golden State Milk Products Company, 425 Battery Street, San Francisco, Calif.
BIERMAN, HARLOW.....c/o Experiment Station, College Park, Md.
BIGELOW, A. P.....Middlesex, Vt.
BOEHR, J. W.....Dairy Department, Stillwater, Okla.

BORLAND, A. A.....Dairy Department, State College, Pa.
BOUDEWYNS, CELESTIN.....R. R. 1, Box 145, Westwood, N. J.
BOUSKA, F. W.....Beatrice Creamery Company, 1526 State Street, Chicago, Ill.
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Faithfully,

G. C. WHITE,

Secretary-Treasurer.

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BOOK REVIEW

CONDENSED MILK AND MILK POWDER—a new and completely revised edition by Professor Otto F. Hunziker—is just off the press. This work is thorough and comprehensive as is everything from the pen of Professor Hunziker.

The author treats exhaustively all phases of sweetened condensed milk—unsweetened condensed milk—milk powder—and dry buttermilk. He describes methods of manufacture—causes of defects—keeping quality—and best methods of marketing of all these products.

The popularity of this book may be judged by the fact that this is the fourth edition, the three previous editions having long since been exhausted. The book is the most important contribution on the condensed milk and milk powder industry. It should be in the library of the teacher, the student or factory man interested in any phase of the condensed milk and milk powder industry. Copies can be secured direct from the author at LaGrange, Illinois.

EVERY BOTTLE FILLED & EMPTIED 8 TIMES, SOAKED & STERILIZED FOR 30 MINUTES IN HOT CAUSTIC SODA SOLUTION
TO FILLERS
SCRUTINIZER
1ST. STAGE COOLING
2ND STAGE COOLING
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INTERNAL STERILIZING 210°
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Economy in Bottle Handling

THIS Giant Barry-Wehmiller unit delivers 180 clean, bacteriologically sterile bottles a minute. Every bottle is soaked for 30 minutes in caustic soda solution, washed by hot water at high pressure, sterilized at 210°, and cooled *without reinfection.* The B-W Soaker-Washer-Sterilizer is designed for economy as well as efficiency. Automatic transference of bottles, combining these processes in one continuous operation makes possible great economy in handling charges. Graduated temperatures prevent breakage of bottles; machinery is carefully designed to avoid wear and tear—repair bills are almost nil.

Exclusive Features

a. Complete mechanical separation of the soaking process, involving the use of caustic soda, from the washing, sterilizing and cooling processes.

b. Construction of soaker pockets, entirely free from lodging places for dirt, to allow easy access for cleaning.

c. Continuous motion in the soaker avoiding wear and tear on the heavier machinery.

d. Complete drainage of bottles as they emerge from soaker.

e. Automatic transference of bottles from one machine to the other.

f. Washing by hot water at high pressure from spindles entirely within the bottle and in close contact with the glass. (No unsanitary brushes.)

g. Complete separation of the carrying chain from interior of the washer and sterilizer, saving wear and tear on the chain and preventing reinfection of the bottles.

h. Step by step motion on the washer to insure thorough cleaning.

i. Cooling by application of water to the exterior only of the bottle.

Six of these B-W units are used in the largest plants of the Sheffield Farms Company, New York City. Adopted by one of the largest European Dairies.

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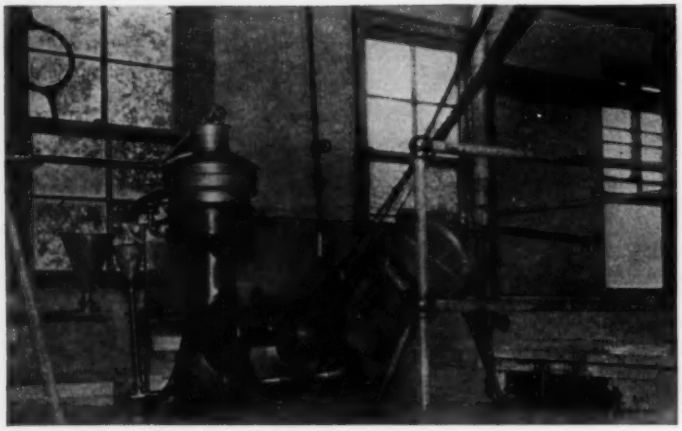

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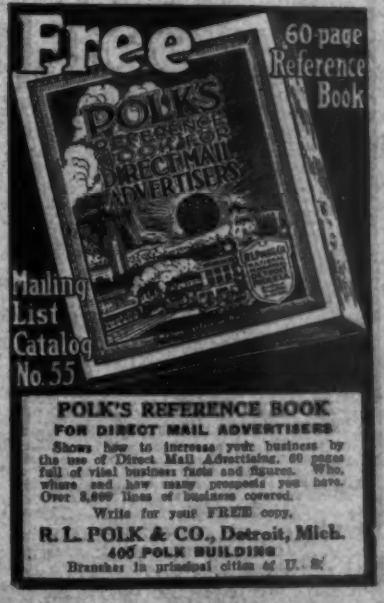

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